

ANALYSES OF REQUIREMENTS FOR COMPUTER CONTROL
AND DATA PROCESSING EXPERIMENT SUBSYSTEMS

IMAGE DATA PROCESSING SYSTEM
IDAPS
SOFTWARE DESCRIPTION (7094 VERSION)

VOLUME II

15 SEPTEMBER 1973

NASA-CR-124447) ANALYSES OF REQUIREMENTS
FOR COMPUTER CONTROL AND DATA PROCESSING
EXPERIMENT SUBSYSTEMS: IMAGE DATA
PROCESSING SYSTEM (System Development
Corp.) 134 p HC \$8.75

N73-33123

CSCL 09B G3/08

Unclassified
15727

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This document contains a description of each of the software modules of the Image DAta Processing System (IDAPS) developed under NASA contract NAS8-25471 during the period September 15, 1972 to September 15, 1973. Much of this software is derived from an earlier effort which was reported in SDC TM-(L)-HU-033/006/00 "ATM Experiment S-056 Image Data Processing System Software Development - Volume II". The changes which this document reflects are the result of additions to the application software of the system and an upgrade of the IBM 7094 Mod I computer to a 1301 disk storage configuration. The addition of the disk to the system eliminates most of the manual steps associated with storing intermediary data files on magnetic tape, thus greatly improving ease of use of the system.

The purpose of this document is to supply necessary information about IDAPS software to the computer programmer who desires to make changes in the software system or who desires to use portions of the software outside of the IDAPS system. Generally, each software module is documented in the following manner:

- Module Name
- Purpose
- Usage
- Common Block(s) Description
- Method (algorithm of subroutine)
- Flow Diagram (if needed)
- Subroutines Called
- Storage Requirements
- Required by: (IDAPS Operator)

A general description of the common blocks used by the IDAPS system is included as Appendix A to this document. Appendix B is an explanation of the diagnostic features of the system, and Appendix C describes in detail the procedure for adding new IDAPS operators to the system.

For the convenience of the user, subroutines herein documented are arranged in alphabetical order.

AREAC (Area Calculations)

Purpose:

AREAC calculates the area on a sphere represented by pixels of a specific value. Aspect ratio is accounted for as a function of the distance to each pixel from the center of the sphere. Also calculated are the centroid of the area, the center of radiation intensity over the area, and the center of total released energy over the area.

Usage:

CALL AREAC

Common block COM1 parameters:

Common name	Local name
IN(5)	JIN - Input file containing subsetted data (output from SUBSET operator)
SN(5)	KIN - Original input image (used with MOMENT operator only)
L	NL - Number of lines
C	NC - Number of columns
K1	CASE - Pixel value for which the area is calculated
K2	LC] - Line and column location of the center of the sphere
K3	KC] with respect to the upper left corner of the original input image
K4	LSF] - Location of the upper left corner of the data
K5	KSF] frame being processed with respect to the upper left corner of the original input image
K6	NTAB - Indicator of the type of aspect correction desired:

	NTAB = 0 - No aspect corrections are applied
	NTAB = 1 - Corrections based on table supplied by user
	NTAB = Other - Internal aspect ratio table used
K7	IORB - Indicator of sphere
	IORB = 1 - Earth
	IORB = Other - Sun
K8	IOP - Operator indicator
	IOB = 1 - AREA calculated only
	IOB = 2 - MOMENT package
A1	SPOT - Size in micrometers of scanning aperture used

Method:

The centroid of a thin plate on the surface of the hemisphere is located in rectangular dimensions by:

$$\bar{x}_s = \frac{\sum c \Delta s}{\sum \Delta s} \quad \bar{y}_s = \frac{\sum g \Delta s}{\sum \Delta s} \quad \bar{z}_s = \frac{\sum l \Delta s}{\sum \Delta s}$$

The values of c and l can be obtained by direct methods and the values of g can be computed as:

$$g = R^2 - l^2 - c^2$$

Δs is the elemental area corresponding to one picture element and located by l , c , and g .

For calculating the center of radiation intensity instead of the area, the above equations must be modified by replacing the elemental area s with an intensity factor. Thus:

$$\bar{x}_i = \frac{\sum c_i}{\sum i} \quad \bar{y}_i = \frac{\sum g_i}{\sum i} \quad \bar{z}_i = \frac{\sum l_i}{\sum i}$$

Likewise, for the center of total released energy, both the rate of energy release (intensity) and the area over which it is released must be taken into account so that:

$$\bar{x}_e = \frac{\sum c_i \Delta s}{\sum i \Delta s} \quad \bar{y}_e = \frac{\sum g_i \Delta s}{\sum i \Delta s} \quad \bar{z}_e = \frac{\sum \ell_i \Delta s}{\sum \Delta s}$$

From the observer's point of view, the centroid of a feature on the sun may more easily be located by spherical coordinates of latitude and longitude (ϕ and θ).

$$\bar{\phi} = \cos^{-1}(\bar{z}/R) \quad \text{and} \quad \bar{\theta} = \tan^{-1}(\bar{y}/\bar{x})$$

Converting the formulas for the centroid, center of intensity, and center of energy:

$$\bar{\phi}_s = \cos^{-1}\left(\frac{\sum \ell \Delta s}{R \sum \Delta s}\right) \quad \bar{\theta}_s = \tan^{-1}\left(\frac{\sum g \Delta s}{\sum c \Delta s}\right)$$

$$\bar{\phi}_i = \cos^{-1}\left(\frac{\sum \ell_i}{R \sum i}\right) \quad \bar{\theta}_i = \tan^{-1}\left(\frac{\sum g_i}{\sum c_i}\right)$$

$$\bar{\phi}_e = \cos^{-1}\left(\frac{\sum \ell_i \Delta s}{R \sum i \Delta s}\right) \quad \bar{\theta}_e = \tan^{-1}\left(\frac{\sum g_i \Delta s}{\sum c_i \Delta s}\right)$$

Subroutines: DISK8, DATAIN, CONVRT

System library routines: ARCOS, SQRT, ATAN

Storage: 12227 (8 words

Required by: AREA, MOMENT

ARITH (Arithmetic Functions)

Purpose: ARITH performs the following point by point operations on two frames of data: A+B, A-B, A*B, A/B. Also A+C, A*C, C/A and A**C, where C is a constant, may be performed.

Usage: CALL ARITH

Common block COM1 parameters:

Common name	Local name
IN (5)	I1, I2 - Input file names for A and B
ON	IO - Output file name
L	NL - Number of lines
C	NC - Number of columns
K1	KF - Operation flag KF = 1 - A+B KF = 2 - A-B KF = 3 - A*B KF = 4 - A/B KF = 5 - A+C KF = 6 - A*C KF = 7 - C/A KF = 8 - A**C
A1	CN - Constant to be used if KF is greater than 4

Subroutines: DISKR, DISKW

Storage: 14243 (8 words

Required by: MATH

ARROW

Purpose: ARROW creates the image of an arrow in a 9x9 matrix.

Usage: CALL ARROW (MAT,INDIC)

MAT - The given 9x9 matrix

INDIC - Arrow direction indicator

INDIC = 1 - SW to NE

INDIC = 2 - SE to NW

INDIC = 3 - NW to SE

INDIC = 4 - NE to SW

Storage: 511 (8 words

Required by: FRAME

ASSIGN (Assign Name)

Purpose: ASSIGN designates a unique name for every input, scratch, and output disk file for an operator.

Usage: CALL ASSIGN (I,IN,SN,ON,NF,LOF,CARD)

I - Operator index into array NF

IN - Input file name array

SN - Scratch file name array

ON - Output file name

NF - Operator parameter table containing the first three characters of each operator's name, and the number of input, scratch, and output files to be assigned for that operator

LOF - Last opened output file

CARD - Operator card image

Method: The operator card image is scanned for the presence of multiple or non-standard input file names enclosed in parentheses. If any are found, they are stored in array IN and replaced by blanks in the card image array. Otherwise, the file found in LOF is stored in IN(1). Standard output file names are established by the following convention:

The first three characters of the operator's name are preceded by an integer constant which represents the numerical order of the file's use. For example, the first time operator CONVOLVE is encountered, the output file is named 1CON; the second time CONVOLVE is encountered, the output file is named 2CON, etc.

Scratch files are named in a similar manner with the addition of the letter S before the operator name. For example, operator TRANSPOSE may have scratch files 1STRA, 2STRA, 3STRA, etc. The integer digit always begins at one for each operator's scratch files because the scratch files are deleted immediately after use.

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Subroutines: UNPACK, ERROR

System library routines: CTOBIN, FLD, MOVST

Storage: 1305 (8 words

BESJ (Bessel Function Generator)

Purpose: BESJ generates all Bessel functions of the first kind having integral order and real argument subject to the restrictions below.

Usage: CALL BESJ (X, N, BJ, D, IER)

X - Argument of the J Bessel function desired

N - Order of the J Bessel function

BJ - Resultant Bessel function

D - Required accuracy

IER - Error code

IER = 0 - No error

IER = 1 - N is negative

IER = 2 - X is negative or zero

IER = 3 - Required accuracy not obtained

IER = 4 - Range of N compared to X not correct

Method: The Bessel functions of the first kind of integral order are computed by recurrence relation techniques described by H. Goldstein and R. M. Thaler, Recurrence Techniques For The Calculation Of Bessel Functions, MTAC, V. 13, pp. 102-108 and A. Stegun and M. Abramowitz, Generation of Bessel Functions On High Speed Computers, MTAC, V. 11, 1957, pp. 255-257.

Restrictions: $N < 20. + 10. x - x^{2/3}$
for $x \leq 15.$
 $N < 90. + x/2.$
for $x > 15.$

Storage: 456 (8 words

CENTR (Center)

Purpose: CENTR multiplies each pixel of an input image by $(-1)^{**}(i+j)$ where i is the line position of the point and j is its column position.

Usage: CALL CENTR

Common block COM1 parameters:

Common name	Local name
IN (5)	IN - Input file name
ON	IO - Output file name
L	NL - Number of lines
C	NC - Number of columns
K1	KF - Data flag KF = 1 - Integer KF = Other - Floating point

Restrictions: The number of columns in the image must be less than or equal to 1024.

Subroutines: DISKR, DISKW

Storage: 2206 (8 words

Required by: CENTER

CKFMT (Check Format)

Purpose: CKFMT compares the format of an input file for an operator with the format required by that operator, and converts the input format if necessary.

Usage: CALL CKFMT (KIF)

KIF - Input file format desired
KIF = 0 - Floating point
KIF = 1 - Integer

Common block COM1 parameters: (See Appendix A)

Method: The format of each input file is determined from the disk directory. If format conversion is necessary, a temporary input file is opened. The name of the original input file is saved in array PN, while the temporary file name replaces it in array IN. The converted data is stored in the temporary file and the original input file is closed.

Subroutines: DISKO, DISKC, IDENT, DISKR, DISKW

System library routine: SSWTCH

Storage: 12246 (8 words

CONV (Convolution Driver)

Purpose: CONV has five entry points which perform the following two-dimensional Fourier transform operations on an input image:

- CONV - Convolution
- DCONV - Deconvolution
- CRLATE - Correlation
- XFORM - FFT
- IXFORM - IFFT

Usage: CALL CONV (IP,MSIZE,IN,NTSIZE,KFLAG,II)
 CALL DCONV (IP,MSIZE,IN,NTSIZE,KFLAG,II)
 CALL CRLATE (IP,MSIZE,IN,NTSIZE,KFLAG,II)
 CALL XFORM (IP,MSIZE,NTSIZE,NOR,II)
 CALL IXFORM (IP,MSIZE,NTSIZE,II)

- IP - Point spread function file name
- MSIZE - Size of point spread function
- IN - Input image file name
- NTSIZE - Size of output file
- KFLAG - Point spread function control flag
 - KFLAG = 1 - Point spread function is being input in frequency domain
 - KFLAG = Other - Point spread function is being input in spatial domain
- II - Scratch disk file name

Common block COM1 parameters:

Common name	Local name
CARD(13)	CARD1(6), RMAG, PHA, CARD9(5) - Input card image
IN(5)	IA - Input disk file names
SN(5)	IW, IWW, SN3, IWWW, SNS - Scratch file names
ON	IO - Output file name
L	NSIZE - Size of input file

Notes: If the point spread function is input in the spatial domain (KFLAG \neq 1), an extra call is made to FRX2V to transform and normalize the PSF.

Restrictions: The point spread function and input image arrays must be square.

Subroutines: FRX2V

Storage: 3456₍₈₎ words

Required by: FFT, IFFT, CORRELATE, CONVOLVE, DECONVOLVE

CONVRT (Convert to Degrees)

Purpose: CONVRT converts a floating point number which represents an angle to integer degrees, minutes and seconds.

Usage: CALL CONVRT (HDG, IDEG, MIN, ISEC)

HDG - Number to be converted

IDEG - Degrees

MIN - Minutes

ISEC - Seconds

Storage: 110₍₈₎ words

DATAIN (Data Input)

Purpose: DATIN reads free field, tabular data from cards and stores it in a specified array.

Usage: CALL DATAIN (X,N,K)

X - Array into which data will be stored

N - Number of data values to be input

K - Data format

K = 0 - Integer

K = 1 - Floating point

Method: Data is input in the following general format:

A = 9.,8.1,6.3,4.2,2.7,1.6,.8,.09,12*0.\$

DATAIN looks for the equal sign and isolates each number separated by commas until a \$ is encountered at which point the input scan is terminated.

Multiple values may be input by using an asterisk, as shown in the example above where 12*0. indicates that 12 zeros are to be input following the value .09.

Integer values are input without decimal points.

Continuation cards are required if data cannot be contained in columns 1 - 78 of the first card. Continuation cards must start in column 2 with column 1 blank.

A check is made for the correct number of input values, as well as the correct format of the data.

Subroutines: UNPACK, PACK, INSERT

System library routines: CTOBIN, MOVST, SSWTCH

Storage: 1021 (8 words

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Required by: ALTER, DEPENDENT ALTER, PSF GENERATOR, FEATHER

DISKO (Disk Open)

Purpose: DISKO has three entry points:

DISKO - Opens a disk file and initializes the file directory
DISKC - Closes a disk file
DISKD - Deletes a disk file

Usage: CALL DISKO (ID, NL, NC, KD, KU, JU)

CALL DISKC (ID)

CALL DISKD (ID)

ID - File identification

NL - Number of lines

NC - Number of columns

KD - Data type

KD = 0 - Floating point

KD = 1 - Integer (6-bit)

KU - Disk unit number to be assigned at time file initially
opened (0 or 1)

JU - Disk unit number that was assigned to a previously opened
file

Method: A disk file may be in one of the following states:

Open and active - The file has been opened but
not closed or deleted: it
can be written or read.

Open and inactive - The file has been opened and
closed but not deleted: it
must be reopened before written
or read.

Deleted - The file has been opened, closed,
and deleted: it cannot be
written or read.

When a file is initially opened, the following entries for
as many as 100 files are made in the file directory:

IDT	- File identification
NLT	- Number of lines in the input image
NCT	- Number of columns per line
KST	- Starting track number
NLPT	- Number of lines per track
NT	- Number of tracks
KDT	- Data type
	KDT = 0 - Floating point
	KDT = 1 - 6-bit integer packed
KP	- Pointer to buffer
	KP = 0 - Buffer closed
	KP = 1-7 - Buffers 1-7
KUT	- Unit specification (0 or 1)
NAF	- Number of assigned files
NOB	- Number of open buffers
LTU	- Last track used - LTU(1) = Unit 0, LTU(2) = Unit 1
ITKADR	- Track address of data currently in buffer (KP)

In addition to the entries made in the file directory, when a file is initially opened a core buffer may be set aside for it. A buffer is required if the number of columns per line requires less than 233 words of storage. Thus, an integer file will use a buffer if a line contains less than 1393 columns since each pixel is 6 bits and 6 pixels are packed into a 36-bit word. The use of buffers reduces the number of accesses required when reading or writing disk, since a full track of data is read into core or written from core for each read or write operation. For example, to read or write a 128 by 128 integer image requires only 7 disk accesses. The following table portrays the layout of various sized images when stored on the disk.

Number of lines per image	Number of columns per line	Number of lines per track (integer format)	Number of tracks per image
1024	1024	2	512
512	512	5	103
256	256	10	26
128	128	21	7
64	64	43	2

Buffers are used only during an operator's execution. Each active file is either closed or deleted following execution of the operator.

Input file(s) - Closed

Scratch file(s) - Deleted

Output file - Closed

If an output file is to be used as the input file for a succeeding operation, it must be reopened.

When a file is closed, the assigned buffer is released but the entries in the file directory for the closed file and the file itself on disk are not changed. When a file is deleted, the buffer is released, the entries for the deleted file in the file directory are deleted, and the file is purged from the disk.

Subroutines: IDENT

System library routines: SSWTCH, EXIT

Storage: 3134 (8 words)

DISKR (Disk Read)

Purpose: DISKR contains two entry points:

DISKR - Reads a section of an image from disk
DISKW - Writes a section of an image to disk

Usage: CALL DISKR (ID,LN,LL)

CALL DISKW (ID,LN,LL)

ID - File identification

LN - Line index. If negative, write backwards (i.e., bottom
to top of image)

LL - Line to be read or written

Method: Pixels are stored on the disk in packed format (6 characters/
word) for integer files and unpacked format (1 character/word)
for floating point files. Lines are buffered when the
column size is less than 1393 (integer) or 233 (floating point).

Subroutines: UPL6, PL6, IDENT

System library routines: SSWTCH, DTAKE, DCHEK, DPUT, EXIT

Storage: 11310 (8 words

DRIVTP (TRNPS Driver)

Purpose: DRIVTP calculates the variable dimensions of the core buffer used in subroutine TRNPS, and calls TRNPS with the correct parameters.

Usage: CALL DRIVTP (REVOLV)

REVOLV - Rotation option indicator
 REVOLV = 1 - TRANSPOSE
 REVOLV = 2 - +90 DEGREE ROTATE
 REVOLV = 3 - -90 DEGREE ROTATE
 REVOLV = 4 - MINOR TRANSPOSE
 REVOLV = 5 - VERTICAL ROTATE
 REVOLV = 6 - HORIZONTAL ROTATE
 REVOLV = 7 - 180 DEGREE ROTATE

Common block COM1 parameters:

Common name	Local name
L	NL - Number of lines
C	NC - Number of columns
K1	FMT - Format of the data FMT = 1 - Integer FMT = Other - Floating point

Method: The maximum number of columns which can be in core is determined by dividing a single 10240 word array by the number of lines in the input image. This calculated dimension, INDEX, is passed to TRNPS where the core buffer is dimensioned dynamically (INDEX, NL).

Subroutines: TRNPS

Storage: 24157 (8 words

Required by: TRANPOSE, +90 DEGREE ROTATE, -90 DEGREE ROTATE, MINOR TRANPOSE,
VERTICAL ROTATE, HORIZONTAL ROTATE, 180 DEGREE ROTATE

DSPLIN (Display Line)

Purpose: DSPLIN converts a string of BCD characters into a 9x171 array for display of alphanumeric characters on the Photowriter or DICOMED display unit.

Usage: CALL DSPLIN (IN, NC, KC, KOUT)

IN - String of characters to be converted to display format
NC - Number of characters in string to be converted,
 excluding trailing blanks
KC - Starting column position in output array
KOUT - Output array (9x171 packed format)

Method: Each BCD character in the input string is interpreted and a corresponding 9x7 bit configuration is placed in the output array.

Restrictions: A maximum of 102 characters can be converted for display at one time.

Subroutines: UNPAC

System library routines: FLD

Storage: 22566 (8 words

Required by: LABEL

DSPLN (Display One Line at a Time)

Purpose: DSPLN converts a string of BCD characters into an array for display of alphanumeric characters on the Photowriter or DICOMED display. This subroutine is used for the line-at-a-time output of labels required by the FRAME and MULTIPLE DISPLAY operators.

Usage: CALL DSPLN (IN,NC,KC,OUT,TP,NUM,LN)

IN - String of characters to be converted for display
in BCD format
NC - Number of characters in string to be
converted
KC - Starting column position in output array
OUT - Output array unpacked
TP - Maximum number of columns in the output array
NUM - Index to first character in the input array
LN - Line number (1-9)

Method: Each BCD character in the input string is interpreted and a corresponding bit configuration is placed in the output array. DSPLN must be called in a loop, 9 times, with LN incremented each time, to effect the correct 9x7 bit character configuration.

Restrictions: A maximum of 80 characters can be converted for display at one time.

System library routines: FLD

Storage: 436 (8 words

Required by: FRAME, MULTIPLE DISPLAY

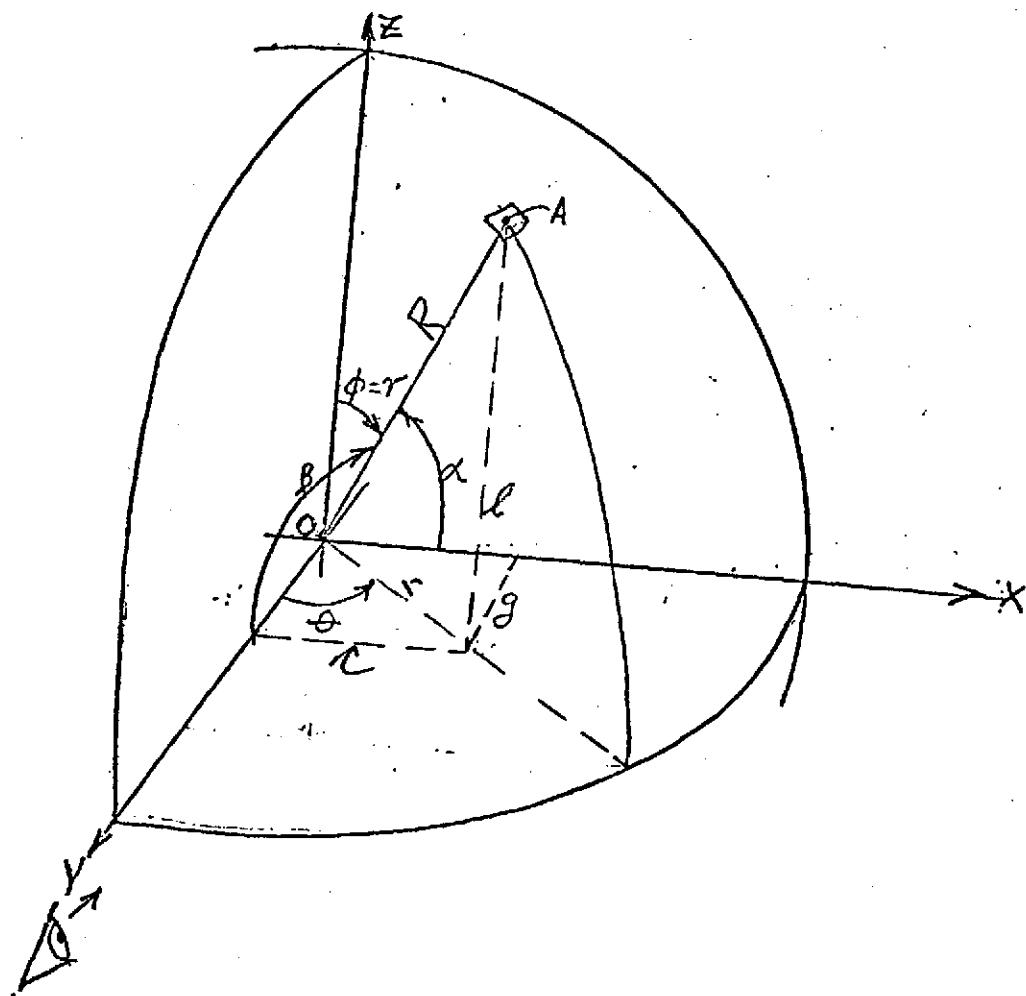
DSTANC (Distance)

Purpose: DSTANC calculates the distance on a sphere from one point to another, given the latitude and longitude of each point.

Usage: CALL DSTANC

Common block COM1 parameters: (See Appendix A.)

Method:



A point (A) is located on the surface of a hemisphere of radius R. Two sets of coordinates are chosen to describe the location of A - spherical coordinates θ , ϕ , and R , and rectangular coordinate angles α , β , and γ .

ϕ = The angle that OA makes with the Z axis.

θ = The angle between the projection of OA on the XY plane and the Y axis.

α = The angle between OA and the X axis.

β = The angle between OA and the Y axis.

γ = The angle between OA and the Z axis.

If the sphere is viewed at a great distance by an observer situated on the Y axis, then all points on the hemisphere will appear as a perpendicular projection on the X/Z plane. All lines which are parallel to a radius vector in the X/Z plane will appear in true perspective while all others will appear foreshortened by some aspect ratio.

From the viewer's observations, the following calculations can be made:

$R = 1/2$ the diameter of the apparent solar disk

$$\phi = \cos^{-1} \left(\frac{\ell}{R} \right)$$

$$\theta = \sin^{-1} \left(\frac{c}{R \sin \phi} \right) = \sin^{-1} \left(\frac{c}{\sqrt{R^2 \ell^2}} \right)$$

$$\alpha = \cos^{-1} \frac{c}{R}$$

$$\beta = \sin^{-1} \frac{\sqrt{c^2 + \ell^2}}{R}$$

$$\gamma = \phi = \cos^{-1} \frac{\ell}{R}$$

$$\alpha = \cos^{-1} (\sin \phi \sin \theta) \quad \phi = \gamma$$

$$\beta = \cos^{-1} (\sin \phi \cos \theta) \text{ and } \theta = \cos^{-1} \left(\frac{\cos \beta}{\sin \gamma} \right)$$

$$\gamma = \phi$$

For two vectors $\overrightarrow{OA_1}$ and $\overrightarrow{OA_2}$, the cosine of the angle between them is:

$$\cos \angle \overrightarrow{OA_1} \overrightarrow{OA_2} = \cos \alpha_1 \cos \alpha_2 + \cos \beta_1 \cos \beta_2 + \cos \gamma_1 \cos \gamma_2$$

Translating this to spherical coordinates:

$$\angle_{OA_1}^{OA_2} = \cos^{-1} (\sin\phi_1 \sin\phi_2 \sin\theta_1 \sin\theta_2 + \sin\phi_1 \sin\phi_2 \cos\theta_1 \cos\theta_2 + \cos\phi_1 \cos\phi_2) \text{ or}$$

$$= \cos^{-1} (\sin\phi_1 \sin\phi_2 (\sin\theta_1 \sin\theta_2 + \cos\theta_1 \cos\theta_2) + \cos\phi_1 \cos\phi_2)$$

$$\text{since, } \sin\theta_1 \sin\theta_2 + \cos\theta_1 \cos\theta_2 = \cos(\theta_1 - \theta_2)$$

Then:

$$\angle_{OH_1}^{OH_2} = \cos^{-1} (\sin\phi_1 \sin\phi_2 (\cos(\theta_1 - \theta_2)) + \cos\phi_1 \cos\phi_2)$$

and the distance between OA_1 and OA_2 is $R \left(\angle_{OA_1}^{OA_2} \right)$.

Subroutines: CONVRT

System library routines: CTOBIN, SIN, COS, ARCCOS, SQRT

Storage: 514 (8 words

Required by: DISTANCE

DUMPF (Dump File)

Purpose: DUMPF has two entry points:

DUMPF - Dumps a disk file to tape

READF - Loads a file from tape to disk

Usage: CALL DUMPF

CALL READF

Common block COM1 parameters:

Common name	Local name
IN (5)	IN - Input disk file names
ON	ON - Output disk file name
L	NL - Number of lines
C	NC - Number of columns
K1	KT - Tape unit number
K2	KF - File number

Subroutines: DISKR, DISKW

System library routines: SKFBIN

Storage: 4275 (8 words

Required by: DUMP FILE, LOAD FILE

DUMPPFD (Dump File Directory)

Purpose: DUMPPFD saves a current copy of the disk file directory on the disk.

Usage: CALL DUMPPFD (LOF,NF)

LOF - Last opened output file

NF - Operator parameter table

System library routines: DPUT, DCHEK

Storage: 2743₍₈₎ words

ERROR

Purpose: ERROR causes the printing of a message on the on-line printer.
 After a pause, the next card is read in from the card reader.

Usage: CALL ERROR (CARD)
 CARD - Array of 13 words containing the packed (6 ch/wd)
 card image

Storage: 103 (8 words

FFIL (Fourier Filter)

Purpose: FFIL filters an input image in the frequency domain.

Usage: CALL FFIL

Common block COM1 parameters:

Common name	Local name
IN(5)	IN(1) - Image file name IN(2) - Filter file name
SN(5)	SN - Scratch files 1 through 5
ON	ON - Output file
L	NL - Number of lines
C	NC - Number of columns

Method: The following sequence of operations is performed:

- 1) The image is transformed using subroutine FFT.
- 2) The transform is converted from real/imaginary to magnitude/phase format.
- 3) The magnitude terms of the transform are multiplied by corresponding terms of the filter.
- 4) The resulting transform in magnitude/phase is converted back to real/imaginary.
- 5) The transform is inverse transformed.

Restrictions:

- 1) The filter must be the same size as the image.
- 2) The image and filter must be square.

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Subroutines: FRX2V, DISKR, DISKW

Storage: 3362 (8 words

Required by: FOURIER FILTER

FLIP (Vertical Rotate)

Purpose: FLIP inverts the order of the elements in a line of data so that column NC becomes column 1, column (NC-1) becomes column 2, etc.

Usage: CALL FLIP (NC,IBUF)

NC - Number of columns in a line

IBUF - Input buffer for one line

Storage: 2070 (8 words

Required by: TRANSPOSE, +90 DEGREE ROTATE, -90 DEGREE ROTATE, MINOR TRANSPOSE, HORIZONTAL ROTATE, VERTICAL ROTATE, 180 DEGREE ROTATE

FLTOFX (Floating to Fixed Point Conversion)

Purpose: FLTOFX converts an input image from floating point to fixed point format.

Usage: CALL FLTOFX

Common block COM1 parameters:

Common name	Local name
IN(5)	IN - Input file name
ON	IO - Output file name
L	NL - Number of lines
C	NC - Number of columns

Method: Each pixel within the image is rounded to the nearest whole number and is output in integer format.

Subroutines: DISKR, DISKW

Storage: 10147 words

Required by: FIX

FRAME (Standardized Frame Mask)

Purpose: FRAME provides a standard frame for a processed image consisting of the following information:

- 1) Gray scale step wedge
- 2) Tic marks along the edges of the image
- 3) Optional grid
- 4) Optional labels, both above and below the image
- 5) Histogram of gray scale distribution
- 6) Border around the image
- 7) Optional arrow to point at an area of interest
- 8) Optional inversion of gray scale values

Usage: CALL FRAME

Common block COM1 parameters:

Common name	Local name
CARD(13)	KARD(13)
IN(5)	ID - Input file
L	TNL - Number of lines
C	TNC - Number of columns
K1	TL - Upper label TL = 0 or blank - No top label TL > 0 - Number of lines in top label
K2	BL - Bottom label BL = 0 or blank - No bottom label BL > 0 - Number of lines in bottom label
K3	G - Grid option G = 0 or blank - No grid G = 1 - Automatic grid G > 1 - User supplied grid increments
K4	OP1 - Gray scale inversion option which inverts the image only

K5	OP2 - Gray scale inversion option which inverts the entire output frame
K6	AL - Arrow point line coordinate
K7	AC - Arrow point column coordinate
K8	INDIC - Arrow direction indicator. If 0, then SW to NE direction is used unless image borders indicate otherwise. INDIC = 1 - SE to NE INDIC = 2 - SE to NW INDIC = 3 - NW to SE INDIC = 4 - NE to SW

Method: The designated information is overlayed on the input image, one line at a time, and written onto an output tape with the gray scale wedge lined up vertically along the right side of the image and the histogram below all specified bottom labels. The completed frame width will be TNC + 106.

Restrictions:

- (1) The input image may not exceed 2048 x 2048.
- (2) Only one arrow may be specified.
- (3) The labels are centered, one 80 column card image per line, over the entire width of the framed image.
- (4) The label may not exceed $(TNC + 106)/10$ characters.

Subroutines: FRAMWR, HISTOW, ARROW, DISKR, DSPLN

Storage: 7022 (8 words

Required by: FRAME

FRAMWR (Frame Write)

Purpose: FRAMWR packs a buffer and writes it on the output tape, A6, a designated number of times (NUM). If the gray scale inversion option is indicated, the inversion is performed before the record is written.

Usage: CALL FRAMWR (RECORD,LEN,IOP,NUM,PL,PACKED)

RECORD - The record to be written out on tape

LEN - Length of the record

IOP - Gray scale inversion option indicator

IOP = 0 - No inversion

IOP = Other - Invert

NUM - The number of times this record is to be written

PL - The packed line buffer

PACKED - The length of the packed buffer

Subroutines: PL6

System library routines: WRITER

Storage: 4127 (8 words

Required by: FRAME

FRXFM (Fast Fourier Transform Routine)

Purpose: FRXFM computes the Fast Fourier Transform of a complex vector using a Radix 4 plus 2 algorithm.

Usage: CALL FRXFM (N2POW,X,Y)

N2POW - $\log_2 N$, where N is the number of elements in the complex array

X - Array containing the real part of the complex vector

Y - Array containing the imaginary part of the complex vector

Notes: The array need be dimensioned only in the calling routine. If a real array is to be transformed, set the Y array elements to zero and proceed as usual.

The transform is performed in place; therefore, the input data is destroyed as the transform is computed.

Method: The routine is a modified implementation of a procedure originally developed by Cooley and Tukey and later improved by Gentleman and Sande.

If N is the size of the vector to be transformed, then the equations describing discrete Fourier transformations are given by:

$$X(j) = \sum_{k=0}^{N-1} A(k) \exp\left(\frac{i2\pi jk}{N}\right) \quad j = 0, 1, \dots, N-1 \quad (1)$$

$$A(k) = \sum_{j=0}^{N-1} X(j) \exp\left(\frac{-i2\pi jk}{N}\right) \quad k = 0, 1, \dots, N-1 \quad (2)$$

If $W = \exp\left(\frac{i2\pi}{N}\right)$ and $W^\alpha = W^{nk}$, then equation (1) can be written in matrix form as

$$\begin{bmatrix} X(0) \\ X(1) \\ \vdots \\ X(N-1) \end{bmatrix} = \begin{bmatrix} W^0 & W^0 & \dots & W^0 \\ W^0 & W^1 & & W^{N-1} \\ \vdots & \vdots & & \vdots \\ \vdots & \vdots & & \vdots \\ \vdots & \vdots & & \vdots \\ W^0 & W^{N-1} & \dots & X^{(N-1)}^2 \end{bmatrix} \begin{bmatrix} A(0) \\ A(1) \\ \vdots \\ A(N-1) \end{bmatrix} \quad (3)$$

In general, equation (4) requires N^2 multiplications and divisions. If, however, N has M factors r_1, r_2, \dots, r_m such that $N = \prod_{i=1}^M r_i$, then T can be decomposed into the product of m elementary transformations, followed by a permutation P of the result:

$$T = P T_m T_{m-1} \dots T_1 \quad (5)$$

Each step T_j is in turn composed of N/r_j transforms of dimension r_j . Since the number of arithmetic operations for a transform of dimension r_j is of the order r_j^2 , the total number of operations for the transformation T is less than $N \sum_{j=1}^m r_j^2 = mNr$ but $N = r^m$ or $\log_r N = m$, therefore computation requires $r_N \log_r N$ arithmetic operations compared with the N^2 operations required by a standard transform. Also by reduction of arithmetic operations, accuracy is improved.

The recursive equations needed to implement the Fast Fourier Transformation routine for arbitrary length records ($r = 2^\alpha$ for all integer α) were derived by G. D. Bergland and are shown below.

$$\begin{aligned}
 & A_p(j_0, j_1, \dots, j_{p-1}, k_{n-p-1}, \dots, k_0) \\
 & = \sum_{k_{n-p}=0}^{r_p-1} A_{p-1}(j_0, j_1, \dots, j_{p-2}, k_{m-p}, \dots, k_0) \cdot \\
 & \quad w_N[j_{p-1}(r_1 r_2 \dots r_{p-1}) + \dots + j_0] k_{m-p}(r_{p+1} \dots r_m) \quad (6)
 \end{aligned}$$

The last entry thus calculated will yield the Fourier sum as

$$x(j_{m-1}, \dots, j_0) = A_m(j_0, \dots, j_{m-1}) \quad (7)$$

in such an order that the index of an x must have its binary bits put in reverse order to yield its index in the array A_m .

In some cases the computation required to evaluate equation (6) can be reduced by regrouping the equation as

$$\begin{aligned}
 & \hat{A}_p(j_0, j_1, \dots, j_{p-1}, k_{m-p-1}, \dots, k_0) \\
 & = \left[\sum_{k_{n-p}=0}^{r_p-1} \hat{A}_{p-1}(j_0, j_1, \dots, j_{p-2}, k_{m-p}, \dots, k_0) w_{r_p}^{j_{p-1} k_{m-p}} \right] \cdot \\
 & \quad w_N^{j_{p-1} (k_{n-p-1} (r_{p+2} \dots r_m) + \dots + k_1 k_n + r_0) (r_1 r_2 \dots r_{p-1})} \quad (8)
 \end{aligned}$$

The bracketed term represents a set of r_p -point Fourier transforms and the complex exponential weights outside the brackets reference each set of results to a common time origin.

The term

$$w_{r_p} = w_N^{N/r_p} = e^{2\pi i / r_p}$$

forms the basis for the complex exponential weights required in evaluating each r_p -point transform, and j_{p-1}, k_{m-p} are the indices of the transform.

If the r_1, r_2, \dots, r_m are all equal to some integer, say α , then the transformation described by the resulting recursive equations is referred to as a Radix α transformation. Cooley and Tukey stated in their original paper that the FFT algorithm is formally most efficient when the number of samples in a record is a power of 3 (i.e., $r_j = 3$) but such an algorithm is only slightly more efficient than a Radix 2 or a Radix 4 routine. Later it was recognized that the symmetries of the sine and cosine weighting functions made the Radix 4 algorithm more efficient than either the Radix 2 or Radix 3 algorithm. Radix 4 algorithms, however, suffer from the severe limitation on acceptable record sizes. To overcome this difficulty Gentleman and Sande developed an algorithm which performs as many iterations of the transform as possible with a Radix 4 routine, and then, if required, performs the last iteration with a Radix 2 routine. A modified version of Gentleman and Sande's algorithm is implemented as the subroutine FRXFM.

If N is the size of the array such that $N = 2^{N2POW}$, then $N2POW$ is divided by two (integer division) to compute the required number of transformations of dimension four ($N4POW$).

Restrictions: The dimension (N) of the input array must be a power of two. If it is not, zeros may be used to buffer it up to a length which is a power of two.

System library routines: COS, SIN

Storage: 1224 (8 words

Required by: FFT, IFFT, CORRELATE, CONVOLVE, DECONVOLVE, FOURIER FILTER

FRX2V (Two-dimensional Fast Fourier Process Driver)

Purpose: FRX2V performs a two-dimensional Fourier transformation by calling the fast Fourier subroutine FRXFM first by rows then by columns. FRX2V also serves as the main processor for the convolution, deconvolution, correlation, transform, normalized transform, and inverse transform processes.

- Usage:

```
CALL FRX2V (NSIZE, NPSIZE, IN, IW, IO, IM, IAPPLY, IP, II,
RMAG, PHA, ITRUNC, TMAX, TMIN)
```

NSIZE - Input image dimension
NPSIZE - Output image dimension
IN - Input image disk file name
IW - Scratch disk file name
IO - Output image disk file name
IM - Forward/Inverse transformation flag
IM = 0 - Forward transformation
IM = 1 - Inverse transformation
IAPPLY - Process control flag
IAPPLY = 1 - Convolve
IAPPLY = 2 - Deconvolve
IAPPLY = 3 - Transform and normalize
IAPPLY = 4 - Correlate
IAPPLY = Other - Transform
IP - Transformed point spread function disk
file name
II - Scratch disk file name
RMAG - Limit on magnitude amplification -- See SPRED2
PHA - Limit on phase amplification -- See SPRED2
ITRUNC - Truncation flag
ITRUNC = 1 - No truncation
ITRUNC = 2 - Truncate values outside of
TMIN and TMAX
ITRUNC = Other - Truncate values outside of
0. and 63.

TMAX - Maximum truncation limit

TMIN - Minimum truncation limit

Method:

A two-dimensional Fourier transformation is achieved by first performing a one-dimensional transformation of each of the rows of the original array and then performing a one-dimensional transformation of each of the columns of the array resulting from the first set of transformations. To better understand this procedure consider the continuous two-dimensional transform of equation (1).

$$h(u, v) = \int_{-\infty}^{\infty} \int_{-\infty}^{\infty} H(X, Y) e^{-i2\pi ux} e^{-i2\pi vy} dxdy \quad (1)$$

If an interval T is divided into N equal parts both horizontally and vertically such that $N\Delta X = N\Delta Y = T$, then the maximum frequency $F = \frac{1}{\Delta X} = \frac{1}{\Delta Y}$. The incremental frequencies are then

$\Delta U = \Delta V = F/N$ so that $\Delta U\Delta X = \Delta V\Delta Y = \frac{1}{N}$. Using the indicies j, k, l, m equation (1) in the discrete case becomes

$$h(l\Delta u, m\Delta u) = \sum_{k=0}^{N-1} \sum_{j=0}^{N-1} H(j\Delta x, k\Delta y) e^{-\frac{2\pi i}{N} jl} e^{-\frac{2\pi i}{N} km} \quad (2)$$

Let $TR(j, m) = \sum_{k=0}^{N-1} H(j\Delta x, k\Delta y) e^{-\frac{2\pi i}{N} km}$

$$TR(j, m) = \sum_{k=0}^{N-1} H(j\Delta x, k\Delta y) e^{-\frac{2\pi i}{N} km} \quad (3)$$

then

$$h(l\Delta u, m\Delta u) = \sum_{j=0}^{N-1} TR(j, m) e^{-\frac{2\pi i}{N} jl} \quad (4)$$

but a one-dimensional discrete Fourier transform over an interval T , sampled N times ($N\Delta X = T$ and $F = \frac{1}{\Delta X}$, $\Delta U = F/N$) is given by

$$T(MAX) = \sum_{k=0}^{N-1} V(k) e^{-\frac{2\pi i}{N} km}$$

Therefore, equation (3) is just N ordinary one-dimensional transforms, one for each row of the picture, and equation (4) is N ordinary one-dimensional transforms, one for each of the columns resulting from the N applications of equation (3).

Image buffering: If the input picture(s) and/or point spread function, have dimensions less than the smallest power of two greater than NPSIZE they are buffered with zeros equally on all sides up to this power. Indeed, for convolution, deconvolution, or correlation this is necessary in order to prevent image overlapping due to the cyclic nature of the Fast Fourier Transform. In general if M is the size of the input picture and L is the size of the point spread function, the NPSIZE should be at least the smallest power of two greater than M + L.

Point spread function transformation: If the PSF is input in the spatial domain, an extra call to FRX2V is made by CONV to transform and normalize the PSF (IAPPLY = 3). The normalization consists of summing the gray levels of all elements of the PSF and dividing each frequency element (both real and imaginary) by this amount. This procedure insures that a unit amount of light will be dispensed for each unit present in the input picture.

Image Centering: The transform of the PSF (real and imaginary) is also multiplied by $(-1)^{i+j}$, $i=1, 2, \dots, \text{NPSIZE}$; $j=1, 2, \dots, \text{NPSIZE}$, for convolution and deconvolution so that the output picture will be centered in the frame.

Clipping: Due to improper amplification of certain frequency terms due to noise, improper PSF, etc., the gray levels obtained from deconvolution may extend over a large dynamic range. The subroutine will determine the maximum and minimum values encountered and will print these on-line. If the

64 levels were divided over this large range one would obtain an output image with little contrast. A much improved image will result if the output is clipped both above and below, with the remaining levels quantized to 64 gray levels. Presently the subroutine clips at 0. and 63., that is, all values below zero are set to 0. and all values above 63 are set to 63. The remaining range is truncated to 64 gray levels.

Data storage:

The figure on the next page represents the data storage layout for a 128 by 128 frame of data. Since the whole picture will not fit into core at the same time, the frame is divided into four sections and each section processed in turn. Frames of data which are 256 by 256, and 512 by 512 are similarly handled to minimize data transfer.

Restrictions:

- 1) The image size must be greater than or equal to 16 by 16 and must be less than or equal to 512 by 512. This should be considered the maximum output image size.
- 2) The output image dimension must be square and must be greater than or equal to NSIZE.
- 3) The inverse operator assumes the input image is square.

Subroutines:

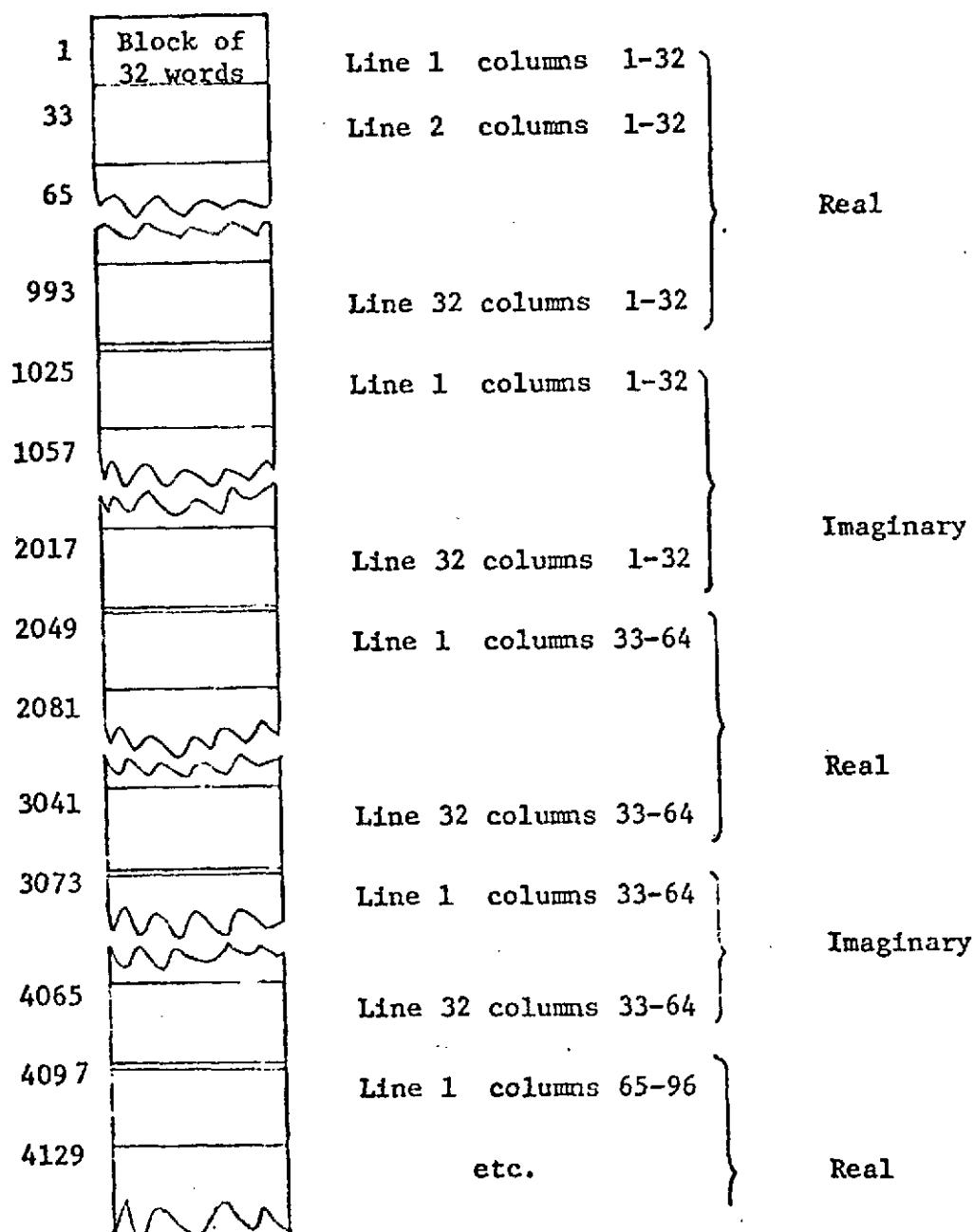
DISKR, DISKW, FRXFM, SPRED1, SPRED2, SPRED3

Storage:

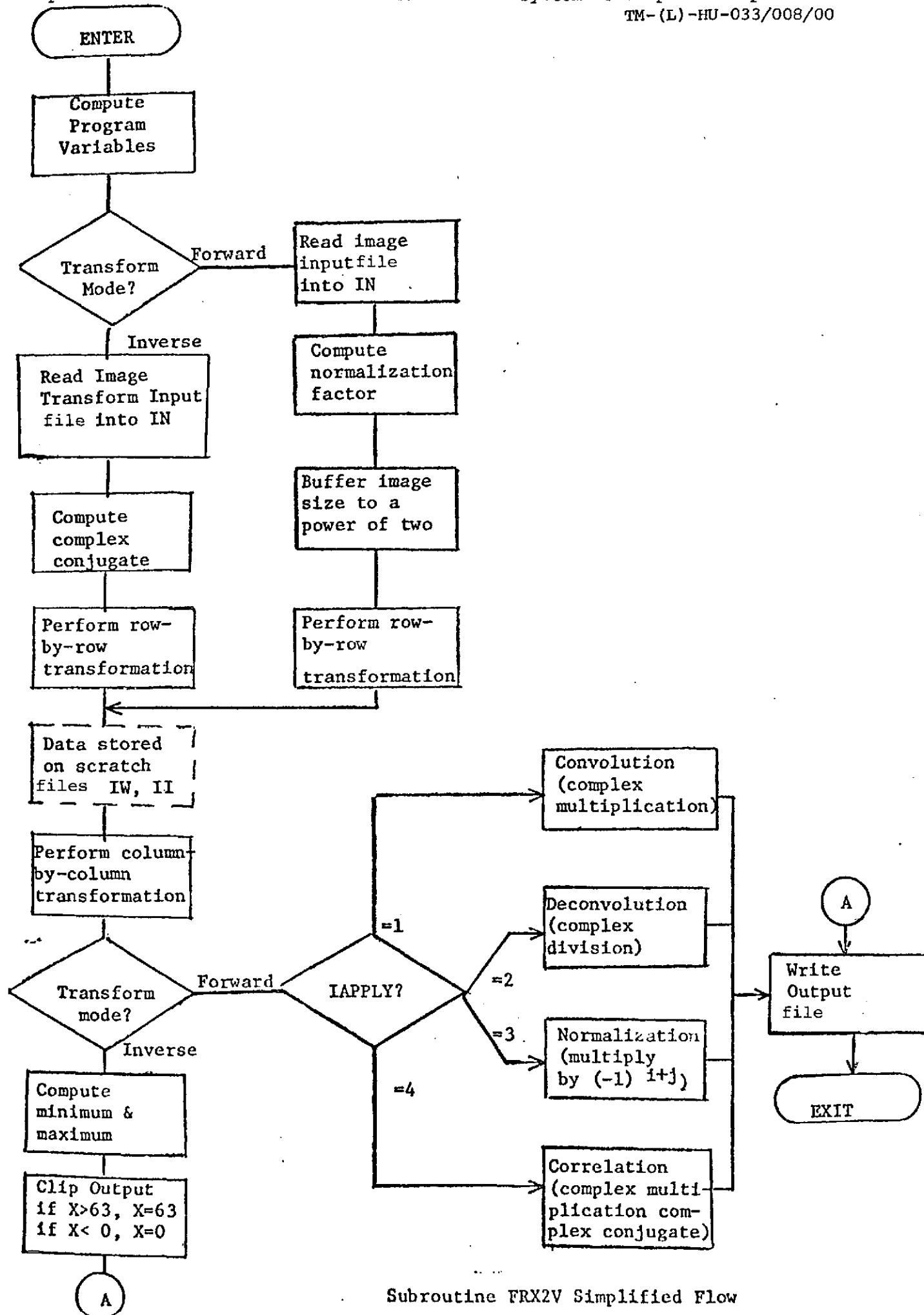
25,520₍₈₎ words

Required by:

FFT, IFFT, CORRELATE, CONVOLVE, DECONVOLVE, FOURIER FILTER



128 x 128 Data Storage Layout



FSIZE (File Size)

Purpose: FSIZE calculates the size of the scratch file needed by the two-dimensional FFT operator, according to the following table:

Image Output Size	Scratch File Size	
	Records	Length
32 x 32	1	1024
64 x 64	1	4096
128 x 128	16	1024
256 x 256	256	256
512 x 512	4096	64
1024 x 1024	65536	16

Usage: CALL FSIZE (NPSIZE, NLines, NCOLMS)

NPSIZE - Output Image Size

NLines - Number of lines in scratch file

NCOLMS - Number of columns in scratch file

Storage: 112₍₈₎ words

FUNGN (Function Generator)

Purpose: FUNGN produces a symmetrical function in a square array from an input curve.

Usage: CALL FUNGN

Common block COM1 parameters:

Common Name	Local Name
ON	IOUT - Output file name
L	L - Number of lines
C	C - Number of columns
K1	K1 - Input option K1 = 1 - Input three horizontal line segments K1 = Other - Input curve profile

Method: The distance from the center of the array is computed for each point in a square array. The distance is used to interpolate a value from the input curve, which is placed into the square array. For distance values outside the range of the input curve corners, the point in the square array is set to the last value found in the curve.

Subroutines: DATAIN, DISKW

System library routines: LAGRNG, COS, SQRT

Storage: 10644 (8 words

Required by: FUNCTION GENERATOR

FXTOFL (Fixed to Floating Point Conversion)

Purpose: FXTOFL converts an input image from fixed point format to floating point format.

Usage: CALL FXTOFL

Common block COM1 parameters:

Common name	Local name
IN (5)	IN - Input file name
ON	IO - Output file name
L	NL - Number of lines
C	NC - Number of columns

Subroutines: DISKR, DISKW

Storage: 10150 (8 words

Required by: FLOAT

HISTOW (Histogram Write)

Purpose: HISTOW generates a histogram from an input array of gray scale totals for output by the FRAME operator.

Usage: CALL HISTOW (GSD, TP, NQ, IOP, PL, PACKED)

 GSD - Array of totals for the 64 gray scale values

 TP - Total number of columns in the final frame

 NQ - Buffer used for generating the gray scale indicators and tics

 IOP - Gray scale inversion option indicator

 PL - Packed line buffer

 PACKED - Length of PL

Subroutines: FRAMWR, DSPLN

Storage: 675 (8 words

Required by: FRAME

HRDCPY (Hardcopy Printout of Images)

Purpose: HRDCPY prints a frame of image data in 1) fixed or floating point format, 2) sixteen levels of gray, or 3) a map of values above a specified threshold.

Usage: CALL HRDCPY

Common block COM1 parameters:

Common name	Local name
IN(5)	JIN - Input file name
L	NL - Number of lines
C	NC - Number of columns
K1	NO - Control flag NO = -4 - Print gray level values on-line in floating point NO = -3 - Print gray level values off-line in floating point NO = -2 - Prints gray level values on-line in integer format NO = -1 - Prints gray level values off-line in integer format NO = 0 to 63 - Prints blanks for values less than or equal to NO and X for values greater than NO NO = 64 - Prints 16 levels of gray using overstrike method
K2	ITOP - Starting line number
K3	JLFT - Starting column number
K4	INES - Number of lines to be printed
K5	KLMNS - Number of columns to be printed

Method: When printing gray level output, HRDCPY divides each gray level value (integer values 0 to 63) by four, adds one and then prints up to nine overstrikes of selected characters to produce one of sixteen different gray levels.

Subroutines: DISKR

Storage: 15104 (8 words

Required by: PRINT

IDAPS2 (Executive Control For IDAPS)

Purpose: IDAPS2 is the main control program for the system and performs, or controls the performance of, the following functions:

- 1) Initialization of the system
- 2) Input and interpretation of IDAPS operators and their associated parameters
- 3) Assignment of input, output, and scratch file names
- 4) Calling the necessary subroutines to execute the operator
- 5) Deletion of the assigned scratch files at the end of execution of each operator
- 6) Closing of input and output files

Common block COM1 parameters: (See Appendix A.)

Subroutines: INIT, SCK, OPL-OP66, OPA-OPH, XPAND, SHADE, PDGSA, MLTAWS, DCONV, RSLGEN, HRDCPY, PSFGEN, CONV, XFORM, IXFORM, CRLATE, SHAVE, FXTOFL, FLTOFX, SPINT, VARY, MAC, LABL, CENTR, MERG, SPLT, RITOMP, MPTORI, ARITH, SCAL, NOSFUG, INIMAG, OTIMAG, STKPIC, MULDSP, FRAME, REWND, DRIVTP, SEGMENT, DUMPF, READF, ISOPLT, ORAND, DELCLS, STAT, INSRT, RESTOR, SHRINK, AREAC, TFGEN, DSTANC, FUNGN, KONVL, SLICE, FFIL, NSA, TIME, DUMPPFD, DISKD, RDC

Storage: 4572 (8 words

IDENT (Identify File Index)

Purpose: IDENT is a function which returns the index to the disk file directory for a specified disk file name.

Usage: INDEX = IDENT (ID)
ID - Disk file name
INDEX - Pointer to disk file directory

Storage: 1663 (8 words

INIMAG (Input Image)

Purpose: INIMAG has two entry points:

INIMAG - Reads an input image in scanner format from
tape unit A5.

OTIMAG - Writes a file onto tape unit A6 in display format.

Usage: CALL INIMAG
CALL OTIMAG

Common block COM1 parameters:

Common name	Local name
IN(5)	IN - Input file name
ON	ON - Output file name
L	L - Number of lines
C	C - Number of columns
K1	KF - File number on input tape (for entry INIMAG) Complement flag (for entry OTIMAG) KF = 1 - Complement KF = Other - No complement
K2	SL - Starting line
K3	SC - Starting column

Subroutines: UPL6, DISKW, DISKR, PL6

System library routines: SKFBIN, SKRBIN, REDTPR, WRITER

Storage: 5046 (8 words

Required by: INPUT IMAGE, OUTPUT IMAGE

INIT (Initialize Operator)

Purpose: INIT contains the following entry points:

INIT - Initializes

RDC - Read card

DELCLS - Delete/Close disk files

OPA-OP66 - Individual operator parameter and disk file
manipulation

<u>Purpose</u>	
Usage:	CALL INIT (I,LOF,NF,NO,KREP) System Initialization
	CALL RDC (I,LOF,NF,NO,KREP) Read and interpret operator card
	CALL DELCLS (I,INX,SNX,PNX,NF) Delete and/or close disk files

CALL OPA (J,K)	Initializes ALTER, FIX, FLOAT
CALL OPB (J)	" DEPENDENT ALTER, FEATHER, SPLIT
CALL OPC (J)	" BAR CHART, PSF GENERATOR
CALL OPD	" R/I TO M/P, M/P TO R/I
CALL OP1	" SIZE
CALL OP2	" EXPAND
CALL OP5	" AVERAGE
CALL OP6	" DECONVOLVE
CALL OP7	" STOP
CALL OP9	" PRINT
CALL OP11	" EXTRACT
CALL OP12	" CONVOLVE
CALL OP13	" FFT
CALL OP14	" IFFT
CALL OP15	" CORRELATE
CALL OP19	" SMOOTH
CALL OP20	" COMMENT
CALL OP24	" LABEL
CALL OP25	" CENTER TRANSFORM
CALL OP26	" MERGE
CALL OP30	" MATH

CALL OP31	Initializes	SCALE
CALL OP33	"	NON-SYMMETRICAL PSF
CALL OP34	"	INPUT IMAGE
CALL OP35	"	OUTPUT IMAGE
CALL OP36	"	STACK
CALL OP37	"	MULTIPLE DISPLAY
CALL OP38	"	FRAME
CALL OPF	"	TRANSPOSE, +90 ROTATE, -90 ROTATE, MINOR TRANSPOSE
CALL OPG	"	VERTICAL ROTATE, HORIZONTAL ROTATE, 180 ROTATE
CALL OP47	"	SUBSET
CALL OP48	"	DUMP FILE
CALL OP49	"	LOAD FILE
CALL OP50 (KQ)	"	ISOGRAM
CALL OPH	"	DELETE FILES
CALL OP53 (NF, ID, NO)	"	INCLUSIVE OR, AND
CALL OP54	"	HISTOGRAM
CALL OP55 (KREP)	"	REPEAT
CALL OP56	"	INSERT
CALL OP57 (KQ1)	"	RESTORE
CALL OP58	"	SHRINK
CALL OP59	"	AREA, MOMENT
CALL OP61 (A, B, E, D)	"	MTF
CALL OP63	"	FUNCTION GENERATOR
CALL OP64	"	FILTER
CALL OP65	"	SLICE
CALL OP66	"	FOURIER FILTER

I - Operator Index

LOF - Last opened output file name

NF - Operator parameter table

NO - Number of operators in NF

KREP - Repeat flag

INX - Input file table

SNX - Scratch file table

ONX - Output file name

A,B,E,D - Independent variable parameters for MTF operator
J - Format desired in files
K - Variable format
KQ - Logical variable used with ISOGRAM operator
JD - Array used with DELETE FILES operator
KQ1 - Logical variable used with RESTORE operator

Common block COM1 parameters: (See Appendix A.)

Method: The entry for each individual operator handles reading any parameters into the block COM1, and the opening of all required input, scratch, and output disk files.

Subroutines: ASSIGN, CKFMT, FSIZE, TSFSZ, DISKD, DISKO, IDENT, PRERUN, DISKC, IPARM.

System library routines: SSWTCH, STRTMR, FLD, MOVST, CTOBIN

Storage: 11342 (8 words

INSERT (Insert Character)

Purpose: INSERT is used by subroutine DATAIN to insert a character into a string of characters.

Usage: CALL INSERT (CHAR, STRING, POS)

CHAR - Character to be inserted

STRING - String into which character is to be inserted

POS - Position in string to insert character

System library routines: FLD

Storage: 100 (8 words

INSRT (Insert Array)

Purpose: INSRT inserts a sub-frame into a specified position in a larger file.

Usage: CALL INSRT

Common block COM1 parameters:

Common Name	Local Name
IN(5)	IN1 - Name of larger disk file IN2 - Name of disk file to be inserted
ON	ON - Output disk file name
L	NL - Number of lines in large file
C	NC - Number of columns in large file
K1	KL - Number of lines in sub-frame
K2	KC - Number of columns in sub-frame
K3	SL - Starting line to start insertion
K4	SC - Starting column to start insertion
K5	KF - Edge modification flag KF = 1 - Smooth edges KF = 2 - Border around sub-frame KF = Other - No modification

Subroutines: DISKR, DISKW

Storage: 21016 8) words

Required by: INSERT

IPARAM (Parameter Check)

Purpose: IPARAM is a function which checks the format of all parameters on an input operator card. If the formats are correct, the parameters are converted to binary and stored in the common parameter area (K(1)-K(8), KV, A1, A2) in COM1. The function returns a -2 if any format discrepancies are discovered, a 0 if all parameters are correctly input.

Usage: IERR = IPARAM (CDNO,JFMT,NO)

CDNO ~ Index to packed input card

JFMT - Expected parameter format

JFMT = 0 - Integer

JFMT = 1 - Floating point

NO - Number of consecutive parameters

to be checked

IERR - Parameter check

IERR = 0 - All parameters input correctly

IERR = -2 - Format error discovered

Common block COM1 parameters:

Common name	Local name
CARD(13)	CARD - Packed card image
IN(5)	IN - Input disk files
L	L - Number of lines
C	C - Number of columns
K1-K8	K(9) - Integer parameters
KV	
A1	A12(2) - Real parameters
A2	

Subroutine: UNPACK

System library routines: CTOBIN

Storage: 365 (8 words

ISOPLT (Isodata Plot)

Purpose: ISOPLT produces an isodata plot of the gray values from an input image.

Usage: CALL ISOPLT (SMOOTH)

SMOOTH - Option flag

SMOOTH = .FALSE. - No spatial integration

SMOOTH = .TRUE. - Spatial integration (averaging) is performed on each pixel of input image.

Common block COM1 parameters:

Common name	Local name
IN (\$)	IDP - Input file name
ON	IDO - Output file name
L	NL - Number of lines
C	NC - Number of columns

Method:

i(7)	i(8)	i(1)
i(6)	x	i(2)
i(5)	i(4)	i(3)

The above is an example of the numbering scheme used in the iso-data contouring routine for identifying the eight neighbors (i) of element x.

The entire picture is smoothed by replacing each neighbor with the average of it and its eight neighbors, i.e.,

$$x = \frac{x + \sum_{n=1}^8 i(n)}{9}$$

Each of the eight neighbors i (1 through 8) are searched to find at least one which is in the same contour plane or in a higher level plane as the center element (x).

Each of the four neighbors (2, 4, 6, and 8) are searched to find at least one which is in a lower contour plane than the center element (x).

Elements for which the neighbor conditions stated above are found to be true are marked as border elements and all others are set to zero.

Subroutines: DATAIN, DISKR, DISKW

Storage: 20774₍₈₎ words

Required by: ISOGRAM

KONVL (Convolve)

Purpose: KONVL applies a 3 by 3 moving window filter to an image by numerically convolving the input array with the 3 by 3 filter.

Usage: CALL KONVL

Common block COM1 parameters:

Common name	Local name
IN (5)	JIN - Input file name
ON	JOUT - Output file name
L	NLIN - Number of lines
C	NCLM - Number of columns

Method: With filter W (J,K), input array I(C,L) and output array O(C,L) where C and L are the column and line coordinates respectively:

$$O(M,N) = \sum_{j=1}^3 \sum_{k=1}^3 W(j,k) I(m-2+j, n-2+k)$$

Subroutines: DATAIN, DISKR, DISKW

Storage: 20407 (8 words

Required by: FILTER

LABL (Label)

Purpose: LABL inserts labels, which are read from input cards, into an image.

Usage: CALL LABL

Common block COM1 parameters:

Common name	Local name
L	NL - Number of lines in output frame
C	C - Number of columns (must be 1024)
K1	NP - Number of label lines to be inserted
K2	JIN - Input tape
K3	JOUT - Output tape

Method: A packed display format tape is read down to the line at which the label is to be inserted. The label is overlayed and the process repeated until all labels have been inserted. The format of the label specification is:

Col. 6	Col. 12	Col. 18	Col. 25	Col. 72
J	K	L		(Any desired label)

J - Number of characters in the label

K - Starting line position on the image

L - Starting column position

The label begins in column 25 and continues for J columns. If the label is longer than 48 characters, it is continued on a second card beginning in column 1.

Each character is a 9x7 matrix with a 9x3 matrix of trailing blanks; therefore, each character occupies 9 lines and 10 columns. Line spacing is controlled by the user - a minimum of 5 lines between labels is recommended.

The character set is:

0 through 9, = ' - () . , * / , A through Z

The label is added to the original image so that the labels essentially overlay the image thus allowing overprinting, if desired.

Subroutines: DSPLIN

System library routines: REDTPR, WRITER

Storage: 3724 (8 words

Required by: LABEL

MESS (Message)

Purpose: MESS is used by the diagnostics package to store and output specific error diagnostics.

Usage: CALL MESS (FLAG)

FLAG - Message indicator

Storage: 426 (8 words

MLTAVS (Multi-Copy Average)

Purpose: MLTAVS computes the average of up to five images.

Usage: CALL MLTAVS

Common block COM1 parameters:

Common name	Local name
IN(5)	T - Input file names
ON	O - Output file name
L	L - Number of lines
C	M - Number of columns
K1	S - Number of images to be averaged

Method: For corresponding pixels of the images to be averaged, the mean gray scale value is calculated. The standard deviation is computed as

$$s = \sqrt{\frac{\sum_{i=1}^n x_i^2 - \left(\frac{\sum_{i=1}^n x_i}{n}\right)^2}{n-1}}$$

Those gray scale values outside 1 standard deviation are eliminated and a new mean value is calculated using only the gray scale values within 1 standard deviation of the original mean.

Restrictions:

- (1) A maximum of 5 images may be averaged
- (2) The maximum size of the images to be averaged is 2048 by 2048.

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Subroutines: DISKR, DISKW

Storage: 3014 (8 words

Required by: AVERAGE

MPTORI (M/P to R/I)

Purpose: MPTORI contains two entry points:

MPTORI - Converts magnitude/phase complex file
(interleaved line by line) to a real/
imaginary complex file (interleaved line
by line).

RITOMP - Converts from a R/I file to a M/P file.

Usage: CALL MPTORI

CALL RITOMP

Common block COM1 parameters:

Common name	Local name
IN (5)	IN - Input file name
ON	IO - Output file name
L	NL - Number of lines
C	NC - Number of columns

Restrictions: The number of columns (NC) must be less than or equal to 1024.

Subroutines: DISKR, DISKW

System library routines: SIN, COS, SQRT, ATAN2

Storage: 10400₍₈₎ words

Required by: M/P TO R/I, R/I TO M/P

MULDSP (Multiple Display Format)

Purpose: MULDSP arranges multiple images into a single frame in display format. Options include the expansion of each image by an expansion factor, and labelling under each row of images.

Usage: CALL MULDSP (INTP, OUTP)

INTP - Input tape logical unit number

OUTP - Output tape logical unit number

Common block COM1 parameters:

Common name	Local name
SN(5)	SCRACH - Scratch disk file name
L	NL - Number of lines
C	NC - Number of columns
K1	NTP - Total number of images to be on output frame NTP < 0 - no white spaces, butt images together NTP \geq 0 - 100 lines of blanks between rows
K2	NPR - Number of images in one row across frame
K3	IOP - Option to invert gray scale values before output IOP = 1 - invert IOP = Other - No inversion
K4	IEXP - Expansion factor (a positive integer)
K5	NLAB - Total number of label cards following operator card

Method: The images are taken from successive files on the input tape, expanded if required, and formatted into a single $n \times 1024$ frame in display format, where n is the variable length made up of $NL * (\text{Number of rows} + 100)$. Designated labels are written underneath the rows of images. A maximum of 102 characters may be written per line.

Restrictions: All input images must be the same size.

Subroutines: DISKR, DISKW, PL6, FRAMWR, DSPLN

System library routines: WRITER

Storage: 11161₍₈₎ words

Required by: MULTIPLE DISPLAY

NOSFUG (Non-Symmetrical Function Generator)

Purpose: NOSFUG produces a non-symmetrical two dimensional function for use as a point spread function in deconvolution or for general filter operations where non-symmetry is necessary.

Usage: CALL NOSFUG

Common block COM1 parameters:

Common name	Local name
ON	JOUT - Output file name
L	N - Number of lines
C	M - Number of columns

Method: The user specifies the non-symmetrical function base in polar coordinates and the function profile as a function of the distance along any radial through the Z-axis extending to the base boundary. The base boundary is defined in polar coordinates (R and Theta). The function profile is defined as a percentage of any radial.

Subroutines: DATAIN, DISKW

System library routines: SQRT, ATAN2, LAGRAN

Storage: 4360 (8 words

Required by: NON-SYMMETRICAL PSF

NSA (Non-Symmetrical Alteration)

Purpose: NSA performs a non-symmetrical alteration of the gray scale of an image based on correction planes which are input on tape unit A5 (8).

Usage: CALL NSA

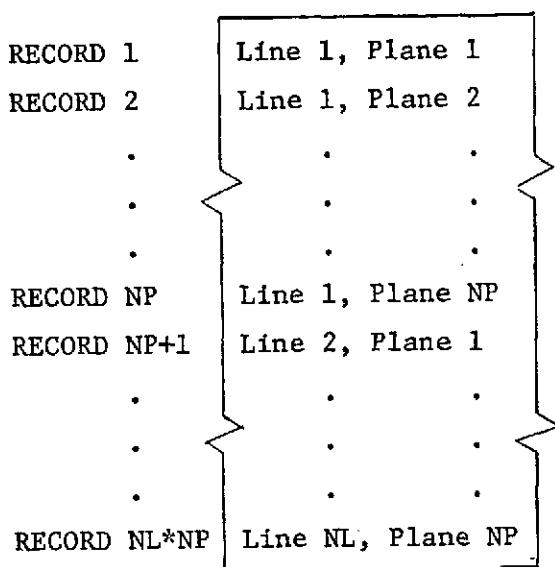
Common block COM1 parameters:

Common name	Local name
IN(5)	IN - Input file name
ON	ON - Output file name
L	NL - Number of lines
C	NC - Number of columns
KV	NP - Number of planes ($3 \leq NP \leq 8$)

Input Data: The actual value of each correction plane is input following the operator card in table form as follows:

CURVE=5., 10., 20., 32., 45., 60.\$

Tape Format: The values in CURVE represent the actual value of the gray scale of each plane. For example, if six planes are to be used for correction, they may be generated by photographing 6 uniform fields of gray scales 5, 10, 20,... as indicated above. The digitized images resulting from photographing the uniform fields are the planes used for correction and are formatted on tape as follows:



The tape, with the correction planes properly formatted, must be generated prior to operation.

Method:

A three-point Lagrange interpolation is performed to find the corrected gray scale value for each pixel in the image. Assume the correction planes are designated X_1, X_2, \dots, X_n . The corrected value, $G(X_{ij})$ is then computed by interpolation as follows: Given the dependent variable table, $X_1(ij), X_2(ij), \dots, X_n(ij)$, as a function of the independent variable table, CURVE, find a value, $G(X_{ij})$, as a function of given argument, X_{ij} .

Restrictions:

- 1) $3 \leq NP \leq 8$
- 2) Number of columns in image must be no greater than 1024.
- 3) Number of columns in correction planes must be equal to number of columns in image.

Subroutines:

DISKR, DISKW, DATAIN

System library routines: LAGRAN, EXIT

Storage: 22406 (8 words

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Required by: FIELD CORRECTION

ORAND (OR/AND)

Purpose: ORAND performs a logical AND or an inclusive OR on two input images.

Usage: CALL ORAND (KO)

KO - Option flag

KO = 1 - Inclusive OR

KO = 2 - AND

Common block COM1 parameters:

Common name	Local name
IN(5)	IN - Input file name
ON	ON - Output file name
L	NL - Number of lines
C	NC - Number of columns

Subroutines: DISKR, DISKW,

Storage: 10222 (8 words

Required by: AND, INCLUSIVE OR

PACK (Pack 6 Characters Per Word)

Purpose: PACK transfers N characters which are stored as the least significant 6 bits of N words into an array where the characters are packed 6 per word.

Usage: CALL PACK (A, N, B)

A - Array of characters to be packed

N - Number of characters

B - Array into which characters will be packed

System library routines: FLD

Storage: 130 (8 words

Required by: ALTER, DEPENDENT ALTER, PSF GENERATOR, FEATHER

PDGSA (Position Dependent Gray Scale Alteration)

Purpose: PDGSA performs a position dependent alteration of the gray scale value of each pixel of an input image.

Usage: CALL PDGSA

Modification tables A and B, of up to 100 values each, represent the coefficients of the linear expression $A + BX$.

Common block COM1 parameters:

Common name	Local name
IN (5)	I - Input file name
ON	O - Output file name
L	L - Number of lines
C	C - Number of columns
KV	N - Length of modification tables A and B

Method: The radial distance of a pixel from the center of the image is computed and is used as the index (m) to tables A and B in calculating a modified value as

$$\text{Modified value} = A_m + B_m \text{ (original value)}$$

The modified value replaces the original value in the image.

Restrictions: All alterations are symmetrical about the center point of the image.

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Subroutines: DATAIN, DISKW, DISKR

System library routines: SQRT

Storage: 20342 (8 words

Required by: DEPENDENT ALTER

PRERUN (Pre-Run Diagnostics)

Purpose: PRERUN checks an input card image for the presence of an equal sign (to indicate a table) or a blank in card column 1 (to indicate a continuation card). This subroutine is only called in the case that sense switch 3 is down (signifying a pre-run diagnostic run) and the scan routine in entry RDC of subroutine INIT has not found a legal operator name in columns 1 - 3.

Usage: CALL PRERUN (CARD, I3C)

CARD - Packed (6 ch/wd) card image
I3C - Card columns 1 - 3

Subroutines: UNPACK

Storage: 101 (8 words)

PSFGEN (Symmetrical Point Spread Function Generator)

Purpose: PSFGEN accepts a curve which defines a point spread function half-profile and creates a three-dimensional PSF array in floating point format.

Usage: CALL PSFGEN

The desired set, of up to 50 floating point values representing the profile of the PSF to be generated, is input in tabular format.

Common block COM1 parameters:

Common name	Local name
ON	JOUT - Output file name
KV	KSIZ - Size of the PSF to be generated

Method: The three-dimensional PSF is generated by rotating the input curve about its left-hand axis. The distance from the center is calculated for each point and a gray value is calculated by interpolating between the input curve points using library routine LAGRNG.

Subroutines: DATAIN, DISKW

System library routines: SQRT, LAGRNG

Storage: 24166 (8 words

Required by: PSF GENERATOR

RESTOR (Restore Disk File Directory)

Purpose: RESTOR restores the copy of the file directory which was saved on disk by operator DUMPFD.

Usage: CALL RESTOR (LOF, NF, DISK)

LOF ~ Last opened output file

NF ~ Operator parameter table

DISK ~ Restore flag

DISK = .TRUE. ~ Restore from disk

DISK = .FALSE. ~ Restore from tape

Common block DISKFD parameters:

Common name	Local name
NLT (100)	ITKO (464)
NCT (100)	
KST (100)	
NLPT (100)	
KDT (100)	
KP (100)	ITK1 (464)
KUT (100)	
IDT (100)	
NAF	
NOB	
LTU (2)	
NT (100)	
ITKADR (7)	

System library routines: DTAKE, DCHECK, DPUT

Storage: 4211 (8 words)

Required by: RESTORE

REWND (Rewind)

Purpose: REWND rewinds and optionally unloads a tape drive. The tape logical unit number and load/unload flag are parameters read from the IDAPS operator card.

Usage: CALL REWND (CARD)

CARD - Packed (6 ch/wd) representation of the operator card image

System library routines: CTOBIN, CLOSE

Storage: 66 (8 words

Required by: REWIND

RSLGEN (Bar Chart Generator)

Purpose: RSLGEN produces a two-dimensional bar chart consisting of alternating groups of black and white bars with spatial frequencies which range from one cycle/line to one-half cycle per column.

Usage: CALL RSLGEN

Common block COM1 parameters:

Common name	Local name
ON	JOUT - Output file name
KV	SIZE - Size of bar chart

Subroutines: DISKW

Storage: 4353 (8 words

Required by: BAR CHART

SCAL (Scale)

Purpose: SCAL scales an input image to values between 0. and 63.

Usage: CALL SCAL

Common block COM1 parameters:

Common name	Local name
IN (5)	IN - Input file name
SN (5)	IS - Scratch file name
ON	IO - Output file name
L	NL - Number of lines
C	NC - Number of columns
K1	KF - Curve flag KF = 1 - Logarithmic (base e) KF = 2 - Square root KF = 3 - Cube root KF = 4 - Square KF = Other - Linear
K2	LF - Clipping flag LF = 1 - Clip outside of BC and TC LF = Other - No clipping
A1	BC - Lower clipping level. All values below BC will be set to zero.
A2	TC - Upper clipping level. All values above TC will be set to 63.

Method: The minimum (MIN) and maximum (MAX) value is determined by comparing each pixel in the image.

The spread is computed as

$$\text{SPREAD} = \text{MAX} - \text{MIN}$$

and the step size, or increment, is

$$\text{STEP} = \text{SPREAD}/64.$$

The file is then rescanned to scale each pixel between 0. and 63. by the desired curve.

Subroutines: DISKRD, DISKWD

System library routines: ALOG, SQRT

Storage: 4476 (8 words

Required by: SCALE

SCK (System Check)

Purpose: SCK is the main program in the diagnostic package. It contains individual checkout sections for each operator. General types of diagnostics made are:

- 1) Check for mandatory non-zero, non-blank parameters
- 2) Check size restrictions on disk files
- 3) Check unique restrictions of each operator

Usage: CALL SCK (ID, *, *)

ID - Operator index
* - Statement numbers in subroutine INIT,
preceeded by \$, to which RETURN 1 and
RETURN 2 refer in subroutine SCK.

Common block COM1 parameters: (See Appendix A)

Subroutines: MESS, SZCK

System library routines: SQRT, SSWTCH, NOW

Storage: 2334 (8 words

SEGMNT (Segment Subsets)

Purpose: SEGMNT investigates an input image and identifies groups of pixels within a common subset. If a point within one subset is given, all other subsets are ignored.

Usage: CALL SEGMNT

Common block COM1 parameters:

Common name	Local name
IN(5)	JIN - Input file names
SN(5)	JSKT, JKST - Scratch file names
ON	JOUT - Output file name
L	NL - Number of lines
C	NC - Number of columns
K1	LL - Lower limit for thresholding. Pixels less than LL are excluded from subset calculation.
K2	LU - Upper limit for thresholding. Pixels greater than LU are excluded from subset calculation.
K3	NULL - Size limit. Subsets smaller than NULL are not included in the subset ID.
K4	LN - Complement tag. LN = 1 - Input file is complemented before processing. LN = Other - Input file is not complemented.
K5	IL - Line coordinate of a point within a subset.
K6	IC - Columns coordinate of a point within a subset .

Method: The SEGMNT subroutine consists of five major sections:

- Pixels which are members of a subset are determined by virtue of their being within the specified upper and lower

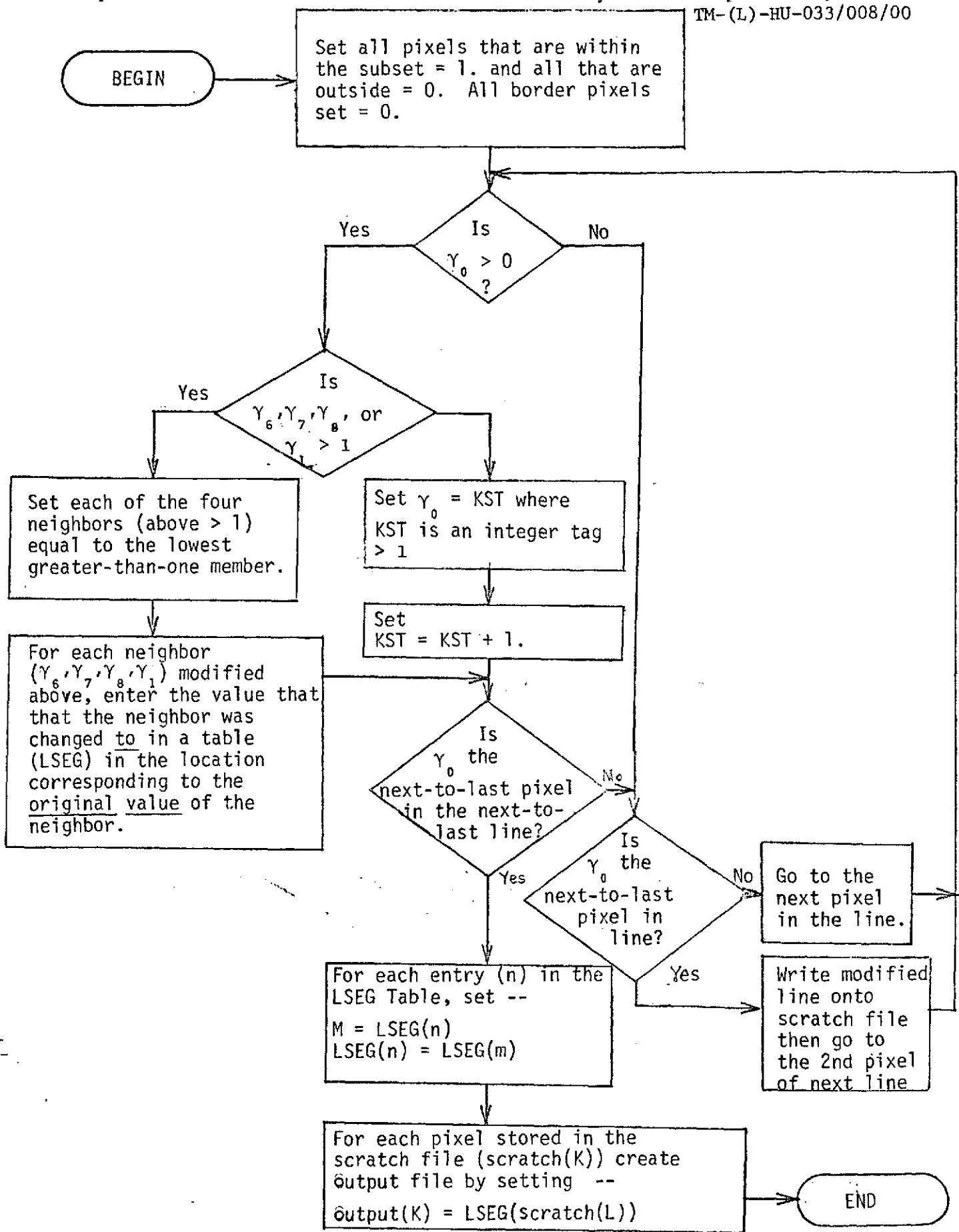
gray scale limits (LL and LU) and their having at least one neighbor within those limits.

- All members of a single subset are identified by assigning each pixel of the subset a unique identification number. If only one subset is desired (IL and IC > 0), all other subset members are set to zero and the desired subset members are set to 63.
- The number of subsets thus identified and the number of pixels which are members of each subset are counted and any subsets smaller than the specified size limit (NULL) are thrown out.
- Subset numbers are reassigned to reflect the relative size of all remaining subsets.
- An output array of subset ID numbers is prepared, and the operator statistics are printed.

The basic algorithm involved is that which identifies members of a single subset. Assuming that a pixel γ_0 has been identified as being a member of a subset and it has neighbors in the following locations:

γ_7	γ_8	γ_1
γ_6	γ_0	γ_2
γ_5	γ_4	γ_3

which may or may not be within a subset, the following flow diagram describes the algorithm in general terms.



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Subroutines: DISKR, DISKW

Storage: 22234 (8 words

Required by: SUBSET

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SHADE (Position Invariant Gray Scale Alteration)

Purpose: SHADE modifies the gray scale values of an image by using the original gray value as an index to a table of modified gray values and replacing the original value with the modified one.

Usage: CALL SHADE

The desired modification set of 64 values is input in tabular format.

Common block Coml parameters:

Common name	Local name
IN(5)	JIN - Input file name
ON	JOUT - Output file name
L	L - Number of lines
C	C - Number of columns

Subroutines: DATAIN, DISKRD, DISKWR

Storage: 465 words

Required by: ALTER

SHAVE (Frame Edge Rounding)

Purpose: SHAVE rounds off the edges of an input image.

Usage: CALL SHAVE

A table of up to 25 real values, representing percentages by which the elements on the edge of the frame will be modified, is entered in tabular format.

Common block COM1 parameters:

Common name	Local name
IN(5)	IN - Input file name
ON	IO - Output file name
L	NL - Number of lines
C	NC - Number of columns
KV	NP - Number of points in modification table

Subroutines: DATAIN, DISKR, DISKW

Storage: 4861 (8 words)

Required by: FEATHER

SHRINK

Purpose: SHRINK reduces the size of an image by an integer factor.

Usage: CALL SHRINK

Common block COM1 parameters:

Common name	Local name
IN(5)	IN - Input file names
ON	ON - Output file name
L	L - Number of lines in the picture
C	C - Number of columns in the picture
K1	IFACT - Shrinkage factor
K2	KOP - Shrinkage method KOP = 1 - Every IFACT'th point KOP = Other - Average of consecutive IFACT x IFACT arrays

Method: An image that is $(\frac{1}{IFACT})$ as large as the original image is formed by first calculating the average of consecutive IFACT x IFACT subarrays from the original image, and then inserting the average value into consecutive pixels in a smaller array.

Restriction: The maximum column size is 1024.

Subroutines: DISKRD, DISKWR

Storage: 10360 (8 words

Required by: SHRINK

SLICE

Purpose: SLICE plots the gray level values found on a line between two points of an image.

Usage: CALL SLICE

Common block COM1 parameters:

Common name	Local name
IN(5)	IN - Input file name
L	L - Number of lines
C	C - Number of columns
K1	IY1 - Line coordinate point 1
K2	IX1 - Column coordinate point 1
K3	IY2 - Line coordinate point 2
K4	IX2 - Column coordinate point 2

Method: The point slope form of the straight line equation is used to find the index of points found on a line between two points.

Subroutines: DISKR

Storage: 10624 (8 words

Required by: SLICE

SPINT (Spatial Integration)

Purpose: SPINT performs a spatial integration of an image by averaging the eight immediate neighbors of each element and adjusting the element by some percentage.

Usage: CALL SPINT

Common block COM1 parameters:

Common name	Local name
IN(5)	JIN - Input file name
ON	JOUT - Output file name
L	NL - Number of lines
C	NC - Number of columns
K1	LMT - Allowable variance within which an element will not be adjusted
K2	KDT - Data type
A1	AJST - Correction factor (stated as a percentage)

Method: Each element E of the frame of data within a 1 element border is surrounded by 8 immediate neighbors N; i.e.,

N	N	N
N	E	N
N	N	N

The mean (\bar{X}) of the 8 neighboring elements is computed for each element within the frame. If the center element is outside a specified limit of the mean of its neighbors, it is replaced by adjusting it as follows:

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New E = E - [E - \bar{X}] . AJST}

For example, if E = 20, \bar{X} = 28, LMT = 2, and AJST = .8 (80%) :

$$\begin{aligned}\text{New E} &= 20 - [(20 - 28) (.8)] \\ &= 20 - (-6.4) \\ &= 26.4 = 26\end{aligned}$$

Restriction: The outer border of the image is unaltered.

Subroutines: DISKR, DISKW

Storage: 20526₍₈₎ words

Required by: SMOOTH

SPLT (Split Data)

Purpose: SPLT has two entries:

SPLT - Splits complex data which is interleaved line-by-line onto real (magnitude) components or imaginary (phase) components.

MERG - Merges the separated complex data line-by-line into one file.

Usage: CALL SPLT
CALL MERG

Common block COM1 parameters:

Common name	Local name
IN(5)	IN - Input file name
ON	IO - Output file name
L	NL - Number of lines
C	NC - Number of columns
KV	NP - Split flag NP = 1 - Split imaginary (or phase) NP = Other - Split real (or magnitude)

Restriction: The number of columns must be less than or equal to 1024.

Subroutines: DISKR, DISKW

Storage: 2234 (8 words

Required by: SPLIT, MERGE

SPRED1

Purpose: SPRED1 performs the multiplication of two complex vectors.

Usage: CALL SPRED1 (N, IP, X, Y, GR, GI, MOL)

N - Size of the arrays

IP - Name of PSF file

X - Real part of iamge transform array

Y - Imaginary part of iamge transform array

GR - Real part of PSF transform array

GI - Imaginary part of PSF transform array

MOL - Line control

Method: Let $I = \text{image} = X + j Y$

$P = \text{PSF} = GR + j GI$

$O_R = \text{real part of resulting image}$

$O_I = \text{imaginary part of resulting image.}$

then $(I)(P) = (X + jY)(GR + j GI) =$

$(X)(GR) - (Y)(GI) + j[(Y)(GR) + (X)(GI)]$

$O_R = (X)(GR) - (Y)(GI)$

$O_I = (Y)(GR) + (X)(GI)$

Restriction: The arrays must be the same size and less than or equal to 1024.

Subroutines: DISKR

Storage: 142 (8 words

Required by: CONVOLVE

SPRED2

Purpose: SPRED2 performs the division of two complex vectors while allowing the limitation of the amount of magnitude change or phase change of the numerator resulting from this operation.

Usage: CALL SPRED2 (NC, IN, IMR, IMI, PSFR, PSFI, NMLIM, NPLIM, MOL)

NC - Number of columns
IN - PSF file name
IMR - Real part of the numerator (image transform)
array
IMI - Imaginary part of the numerator array
PSFR - Real part of the denominator (PSF transform)
array
PSFI - Imaginary part of denominator array
NMLIM - Limit on magnitude amplification (integer)
NMLIM = Blank - No limit
NMLIM = 0 - Allow no magnitude change
NMLIM = Other - Limit all amplifications
greater than NMLIM to NMLIM
NPLIM - Limit on phase amplification (integer)
NPLIM = Blank - No limit
NPLIM = 0 - Allow no phase change
NPLIM = Other - Limit all phase changes
whose magnitude is greater
than NPLIM to NPLIM.
MOL - Line control

Method: The real/imaginary components are converted into magnitude/
phase components.

Let A = image magnitude vector
 θ = image phase vector

B = PSF magnitude vector

θ = PSF phase vector

C = resulting magnitude vector

α = resulting magnitude vector

$$\underline{C/\alpha} = \frac{\underline{A/\theta}}{\underline{B/\theta}} = \frac{\underline{A}}{\underline{B}} / \underline{\theta - \theta}$$

If NMLIM = Blank - operation above is carried out for all PSF points not equal to zero. If a PSF point is equal zero, the corresponding point of the image magnitude vector is unaltered.

If NMLIN = 0 - each point of B is set to one.

If NMLIN = Other - for those points such that $1/B_i$ is greater than NMLIN, set $1/B_i$ to NMLIN.

If NPLIM = Blank - operation above is carried out completely.

If NPLIM = 0 - θ is set to zero.

If NPLIM = Other and $|\theta|$ is greater than MPLIM, θ is set to sign (θ) times NPLIM.

Restriction: The arrays must be the same size and less than or equal to 1024.

Subroutines: DISKR

System library routines: CTOBIN, SQRT, ATAN2, COS, SIN

Storage: 450 (8 words

Required by: DECONVOLVE

SPRED3

Purpose: SPRED3 performs the multiplication of two complex vectors, and computes the complex conjugate of the result.

Usage: CALL SPRED3 (N,IP,X,Y,GR,GI,MOL)

N - Size of the arrays

IP - Name of PSF file

X - Real part of image transform array

Y - Imaginary part of image transform array

GR - Real part of PSF transform array

GI - Imaginary part of PSF transform array

MOL - Line control

Method: Let $I = \text{image} = X + j Y$

$P = \text{PSF} = GR + j GI$

O_R = real part of resulting image

O_I = imaginary part of resulting image

then $(I) \cdot (P) = (X + jY) \cdot (GR + j GI) =$

$(X) (GR) - (Y) (GI) + j [(Y) (GR) + (X) (GI)]$

$O_R = (X) (GR) - (Y) (GI)$

$O_I = -(Y) (GR) - (X) (GI)$

Restrictions: The arrays must be the same size and less than or equal to 1024.

Subroutines: DISKR

Storage: 142 (8 words

Required by: CORRELATE

STAT (Statistics)

Purpose: STAT produces a histogram of the distribution of the gray scale values of an image and computes the following statistics:

Sum of gray scale values
Mean gray scale value
Average deviation
Variance
Standard deviation
Isolated maximum and minimum points

Usage: CALL STAT

Common Block COM1 Parameters:

Common name	Local name
IN	IN - Input file name
L	NL - Number of lines
C	NC - Number of colum

Subroutines: DISKRD

System library routines: SQRT

Storage: 5063 (8 words

Required by: HISTOGRAM

STKPIC (Stack Frames of Data on Tape)

Purpose: STKPIC transfers an image from disk and stacks it on tape.

Usage: CALL STKPIC (IO)

IO - Output tape logical unit number

Note: The output tape, IO, is not rewound, and no end of file is written after the last record.

Common block COM1 parameters:

Common name	Local name
IN	IN - Input file name
L	NL - Number of lines
C	NC - Number of columns

Subroutines: DISKR

Storage: 1153 (8 words

Required by: STACK

SZCK (Size Check)

Purpose: SZCK is used by the diagnostic package to provide size information about existing input files (found in the disk file directory).

Usage: CALL SZCK (IN, ISIZE)

IN - Input file array

ISIZE - Array containing the number of lines and
number of columns of each file in IN.

Storage: 1716₈) words

TFGEN (Transfer Function Generator)

Purpose: TFGEN generates a transfer function from user-provided independent variables.

Usage: CALL TFGEN (A,B,C,D)

A - Independent variable
B - Independent variable
C - Independent variable
D - Independent variable

Common block COM1 parameters:

Common name	Local name
CARD(13)	CARD - Input card image (packed)
ON	ON - Output disk file name
L	NL - Number of lines
C	NC - Number of columns
K1	K1 - Transfer function code K1 = 1 - Polynomial K1 = 2 - Delta function K1 = 3 - Gaussian K1 = 4 - MTF of defocussed perfect lens K1 = 5 - Quarter wave of zero order Bessel function

Method: Based on the basic transfer function profile specified by the user and any required independent variables that must be provided for the selected profile, a one dimensional table is generated from the appropriate mathematical expression. The table length is selected equal to the number of picture elements from the center of the two dimensional output array to its outer edge.

The function profile curve is then "rotated" about the center point to generate a two dimensional output array having such rotational symmetry that any plane passing through the center point, normal to the base, will contain the original one dimensional profile curve and its mirror image. This is done by calculating the distance of every picture element in the output array from the center element and then finding the value for that element on the profile curve. A Langrangian interpolation technique is used to find values for those point-to-center distances which are not an integer number of picture elements.

The two dimensional array of real data values is written as an output file and the values of the one dimensional profile from which the array was produced are printed on the on-line printer.

The transfer functions $T(x)$ have the following mathematical formulae --

$$K = 1 \quad T(x) = A + Bx + Cx^2 + Dx^3$$

$$K = 2 \quad T(x) = A \quad \begin{aligned} &\text{where line} = B \\ &\text{and column} = C \\ &= 0 \quad \begin{aligned} &\text{where line} \neq B \\ &\text{and column} \neq C \end{aligned} \end{aligned}$$

(If no B and C are specified, the center point = A)

$$K = 3 \quad T(x) = Be^{-\frac{1}{2}(\frac{3x}{A})^2}$$

$$K = 4 \quad T(x) = \frac{2}{\pi} [\cos^{-1}(\frac{x}{A}) - \frac{x}{A} \sqrt{1 - (\frac{x}{A})^2}] [\frac{2J_1(K)}{K}]$$

$$0 \leq (\frac{x}{A}) \leq 1.$$

$$= 0 \quad \frac{x}{A} > 1.$$

$$\text{where } K = 8\pi B(\frac{x}{A})(1 - (\frac{x}{A}))$$

$J_1(K)$ = First order Bessel function of K

$$K = 5 \quad T(x) = 2.405 J_0(\frac{x}{A}) \quad 0 \leq (\frac{x}{A}) \leq 1.$$

$$= 0 \quad (\frac{x}{A}) > 1.$$

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Subroutines: DISKW, BESJ

System library routines: SQRT, ATAN2, LAGRAN

Storage: 11046₍₈₎ words

Required by: MTF

TIME

Purpose: TIME prints out the time required to execute the preceding operator, if sense switch 5 is not down.

Usage: CALL TIME (KSS)

KSS - Time at beginning of operator's execution.

System library routines: SSWTCH, NOW

Storage: 72 (8 words

TRANS (Transpose)

Purpose: TRANS performs a transposition, and associated operations, on a core buffer, and writes the final image out on the output file (A6).

Usage: CALL TRANS (OUTB, COREB, OUTF, NL, NUM, F, MAXC, IT, INDEX,
REVOLV)

OUTB - Output buffer

COREB - Core buffer

OUTF - Output file on disk

NL - Number of lines in the image

NUM - Number of columns to transpose as rows

F - Format

F = 1 - Integer

F = 0 - Floating Point

MAXC - Maximum number of lines to write (actual number
of unpacked characters in original line)

IT - Current line on output disk file. If negative, then a horizontal rotation has been selected.

INDEX - Variable dimension indicator for COREB

REVOLV - Transposition option indicator

REVOLV = 1 - Transpose only. (IT = 1)

REVOLV = 2 - Transpose and vertical rotate. (IT = 1).

REVOLV = 3 - Transpose and horizontal rotate.

$$(IT = -NC).$$

REVOLV = 4 - Transpose and both. (IT = -NC).

Subroutines: FLIP, DISKW

System library routines: FLD

Storage: 363 (8 words)

Required by: TRANSPOSE, +90 DEGREE ROTATE, -90 DEGREE ROTATE, MINOR
TRANSPOSE, VERTICAL ROTATE, HORIZONTAL ROTATE, 180 DEGREE ROTATE

TRNPS (Transposition Control)

Purpose: TRNPS controls the rotations required by the following operators:

- 1) TRANSPOSE
- 2) +90 DEGREE ROTATE
- 3) -90 DEGREE ROTATE
- 4) MINOR TRANSPOSE
- 5) VERTICAL ROTATE
- 6) HORIZONTAL ROTATE
- 7) 180 DEGREE ROTATE

Usage: CALL TRNPS (COREFL, INDEX, REVOLV, NL)

COREFL - Buffer of core storage

INDEX - Variable which dynamically dimensions COREFL
to maximum advantage

REVOLV - Rotation options indicator

REVOLV = 1 - Transpose (used for TRANSPOSE
operator)

REVOLV = 2 - Transpose and Vertical Rotate
(used for +90 DEGREE ROTATE operator)

REVOLV = 3 - Transpose and Horizontal Rotate
(used for -90 DEGREE ROTATE operator)

REVOLV = 4 - Transpose and both Vertical and
Horizontal Rotate (used for MINOR
TRANSPOSE operator)

REVOLV = 5 - VERTICAL ROTATE

REVOLV = 6 - HORIZONTAL ROTATE

REVOLV = 7 - Both Vertical and Horizontal Rotate
(used for 180 DEGREE ROTATE operator)

NL - Number of lines in input image

Common block COM1 parameters:

Common name	Local name
IN(5)	INFILE - Input file name
SN(5)	SCRACH - Scratch file names
ON	OUTFIL - Output file names
L	NL - Number of lines
C	NC - Number of columns
K1	FMT - Format of the data FMT = 1 - Integer FMT = Other - Floating point

Method: The input image is stored in COREFL and up to 5 scratch files. The core memory portion is transposed and written on the output file. Each scratch file is transferred to memory, one core buffer section at a time, and transposed and output in the same way. If possible, the scratch files are dimensioned the same size, or a multiple of the size, of the core buffer to minimize disk transfer time.

Restrictions: The maximum image size is 2048 x 2048.

Subroutines: DISKR, DISKW, FLIP, PL6, TRANS

Storage: 3145 (8 words

Required by: TRANSPOSE, +90 DEGREE ROTATE, -90 DEGREE ROTATE, MINOR TRANSPOSE, VERTICAL ROTATE, HORIZONTAL ROTATE, 180 DEGREE ROTATE

TSFSZ (Transpose Scratch File Size)

Purpose: TSFSZ calculates the optimum sizes for the scratch files used by the TRANSPOSE and other related operators.

Usage: CALL TSFSZ (NL, NC, FMT, NO, KFN)

NL - Number of lines in original image

NC - Number of columns in original image

FMT - Format of original image

FMT = 1 - Integer

FMT = 0 - Floating point

NO - Dummy integer. Returns number of scratch files to be opened.

KFN - Dummy array. Returns size (number of columns) calculated for each scratch file.

Method: The optimum size of the scratch files to be opened is determined by the following considerations:

- 1) There may be a maximum of 5 scratch files opened.
- 2) The disk files should fit into the core buffer, with one core block per disk file, if possible. If not, the size of the disk file should be a multiple of the size of the core buffer (10240).
- 3) If unequal sizes are necessary between the five files, the last, or fifth, file should contain the overflow.

Storage: 272 (8 words

Required by: TRANSPOSE, +90 DEGREE ROTATE, -90 DEGREE ROTATE, MINOR TRANSPOSE, VERTICAL ROTATE, HORIZONTAL ROTATE, 180 DEGREE ROTATE

UNPAC (Unpack 1 character from packed array)

Purpose: UNPAC is a function which extracts the j^{th} character from a packed array.

Usage: $B = \text{UNPAC}(A, J)$

A - Array of packed data

J - Index of character to be unpacked

B - Desired character right justified with leading zeros

System library routines: FLD

Storage: 103 (8 words)

UNPACK (Unpack 1 character from packed array)

Purpose: UNPACK is a function which extracts the j^{th} character from a packed array.

Usage: $B = \text{UNPACK}(A, J)$

A - Array of packed data

J - Index of character to be unpacked

B - Desired character, right justified with leading
blanks

System library routines: FLD

Storage: 103 (8 words)

Required by: ALTER, DEPENDENT ALTER, PSF GENERATOR, FEATHER

UPL6 (Unpack Line - 6 Characters/Word)

Purpose: UPL6 contains two entry points:

UPL6 - Unpacks 6 bit characters (6 char/word to 1 char/word).

PL6 - Packs 6 bit characters (1 char/word to 6 char/word).

Usage: CALL UPL6 (LP, SC, NC, LU)

CALL PL6 (LU, SC, NC, LP)

LP - Packed line

SC - Starting character to be packed/unpacked

NC - Number of characters to be packed/unpacked

LU - Unpacked line

System library routines: FLD, PCKINT, UNPINT

Storage: 543 (8 words

XPAND (Frame Expansion)

Purpose: XPAND performs an expansion or an extraction of a selected portion of an image.

Usage: CALL XPAND (NP)
NP - Expansion factor

Common block COM1 parameters:

Common name	Local name
IN (5)	JIN - Input file name
ON	JOUT - Output file name
L	L - Number of lines in original frame
C	C - Number of columns in original frame
K1	LUL - Left upper line element number
K2	LUC - Left upper column element number
K3	NE - Number of lines in extracted portion of image
K4	NC - Number of columns in extracted portion of image

Method: Each line of the original image is read from the input tape and each element within the area to be expanded is duplicated NP times. Each line of data is then output NP times on the output tape. To extract rather than expand a selected portion of an image, NP should be set to 1.

Restrictions: The product of the size of the area to be expanded or extracted and NP may not exceed 2048.

Subroutines: DISKR, DISKW

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System library routines: EXIT

Storage: 10302 (8 words

Required by: EXPAND, EXTRACT

APPENDIX A

COMMON BLOCKS

COMMON/COM1/CARD,IN,SN,ON,PN,L,C,K1,K2,K3,K4,K5,K6,K7,K8,KV,A1,A2

Common block COM1 is used by the IDAPS system to store information used throughout the system. Although called by various local names, the information can be generally defined as follows:

CARD(13)	- Input operator card image, packed six characters per word
IN(5)	- Array of assigned input file names
SN(5)	- Array of assigned scratch file names
ON	- Output file name
PN(5)	- Temporary file names used for format conversion of input files
L	- Number of lines, as defined by the last processed SIZE operator
C	- Number of columns, as defined by the last processed SIZE operator
K1-K8	- Integer parameters from operator card
KV	- Integer parameter from operator card
A1,A2	- Real parameters from operator card

COMMON/DISKFD/NLT,NCT,KST,NLPT,KDT,KP,KUT,IDL,NAF,NOB,LTU,NT,ITKADR

Common block DISKFD is used by the IDAPS system as a disk file directory containing information about all disk files (up to 100) which are opened. The directory is divided into arrays which can be defined as follows:

NLT(100)	- Number of lines in the image
NCT(100)	- Number of columns in the image
KST(100)	- Starting track number
NLPT(100)	- Number of lines per track
KDT(100)	- Data type KDT = 0 - Floating point KDT = 1 - 6-bit integer packed

KP(100)	- Pointer to buffer KP = 0 - Closed KP = 1-7 - Buffer 1-7
KUT(100)	- Unit specification (0 or 1)
IDT(100)	- File identification
NAF	- Number of assigned files
NOB	- Number of open buffers
LTU(2)	- Last track used
NT	- Number of tracks
ITKADR(7)	- Track address of data currently in buffer KP

COMMON/BREAK/KBREAK

Common block BREAK is used to relay the information that the break key (sense switch 2) has been pressed by the user.

COMMON/PRD/IERR

Common block PRD is used to relay the information that an error condition has been discovered by the diagnostic package.

COMMON/TIMS/KSS

Common block TIMS is used to store the starting time for an operator's execution, when the timing option (sense switch 5) is discovered.

COMMON/COM2/Y,GR,GI

Common block COM2 is used to store intermediate results and to share common buffers between the Fourier filtering subroutines (FRX2V, CONV, and FFIL). The names and dimensions defined for COM2 in the subroutines are as follows:

<u>FRX2V</u>	<u>CONV</u>	<u>FFIL</u>
Y(512)	DUM(1536)	FIPIC(512)
GR(512)		EIPIC(512)
GI(512)		FILTER(512)

APPENDIX B
DIAGNOSTICS

IDAPS' diagnostics package produces error messages which are output on the on-line printer. One group of these messages, primarily concerned with syntax errors, originates from the pre-run diagnostics subroutine, SCK, and is stored in subroutine MESS. Following printout of one of this group of messages, two paths of operation may be followed. If the system is in the pre-run diagnostic mode (sense switch #3 down), the checkout of the remaining input cards is continued. During normal execution, however, the system pauses and awaits input of a corrected card before continuing execution. No execution of the incorrect operator is performed, any opened input disk files are closed, and output and scratch files for that operator are deleted. The following chart lists the non-fatal error messages in this group, the IDAPS operators to which they apply, and a brief explanation of each.

DIAGNOSTICS	OPERATORS	EXPLANATION
NON-BLANK PARAMETER REQUIRED		A blank occurs where a number must be.
TAPE LOGICAL UNIT NUMBER MUST BE 8, 10, or 11	LABEL DUMP FILE LOAD FILE	Wrong number given for tape parameter.
INPUT FILE PARAMETER INCORRECT	AVERAGE LOAD FILE	Number of files parameter is either too many or missing.
WRONG NO. INPUT FILE NAMES SPECIFIED	AVERAGE CONVOLVE CORRELATE MERGE MATH INCLUSIVE OR AND INSERT MOMENT	Number of files listed not equal to number of files designated by a parameter, or by definition of the operator.
INPUT FILES MUST BE THE SAME SIZE	AVERAGE MOMENT FOURIER FILTER	Lines and columns of two or more input files are not equal.
INPUT FILES MUST BE SQUARE	DECONVOLVE CONVOLVE CORRELATE FOURIER FILTER	Lines are not equal to columns in input file(s).
DIMENSION MUST BE A POWER OF 2	DECONVOLVE BAR CHART CONVOLVE CORRELATE	Dimension of input file is not a power of 2 between 32 and 512.
DECONVOLVED IMAGE LESS THAN INPUT IMAGE	DECONVOLVE	Parameter designated size of square deconvolved image is less than the number of lines in the input file.
PSF GREATER THAN INPUT IMAGE	DECONVOLVE	Parameter designated the size of the square PSF is greater than the number of lines in the input file.

DIAGNOSTICS	OPERATORS	EXPLANATION
LINES AND COL. OF 2ND FILE MUST = COL. OF 1ST	FOURIER FILTER	Number of lines of the square second input file does not equal the number of columns of the first input file.
N CANT BE LESS THAN HALF THE PICTURE DIAGONAL	DEPENDENT ALTER	Parameter N is less than $\sqrt{\left(\frac{NL}{2}\right)^2 + \left(\frac{NC}{2}\right)^2}$
MOD CONTAINS MORE THAN 25 VALUES	FEATHER	Parameter designated the number of values in table MOD is greater than 25.
FILE MUST HAVE 1024 COLUMNS PER LINE	LABEL	Input file has less than or more than 1024 columns.
NON-ZERO PARAMETER REQUIRED	SIZE	A zero number of lines or columns is illegal.
OPERATION FLAG OUT OF BOUNDS	MATH	Parameter is either less than 1 or greater than 8.
FRAMES ON ROW GREATER THAN TOTAL NO. FRAMES	MULTIPLE DISPLAY	Parameter indicating the number of pictures/row must be less than the total number of pictures.
PSF IS GREATER THAN 100	PSF	Parameter indicating the size of the PSF is greater than 100 or less than zero.
RESOLUTION CHART IS LARGER THAN 2048	BAR CHART	Parameter indicating the size of the bar chart is greater than 2048.
PARAMETER OUT OF BOUNDS	FIELD CORRECTION SCALE	Parameter less than 3 or greater than 8 for FIELD CORRECTION. Minimum clipping value greater than maximum clipping value for SCALE.
LARGER FILE MUST PRECEDE SMALLER ONE	INSERT	Second input file is larger than first input file.
SUBFRAME MUST FIT +2 WITHIN LARGER ARRAY SUBFRAME OVERLAPS EDGES OF LARGE ARRAY	INSERT	Size of second input file too big to allow insertion into first input file.
NO. LINES OF 1ST FILE MUST BE 2*NO. COLS.	FOURIER FILTER	Incorrect size for input file.
NO. COLUMNS MUST BE NO GREATER THAN 1024	FIELD CORRECTION	Number of columns of input file greater than 1024.

Special disk file diagnostic messages handle errors which occur when the disk is being read or written on and during the file directory bookkeeping. These messages generally indicate irrecoverable error conditions and an exit from the IDAPS system occurs.

Other execution time diagnostics are not fatal. Either execution is continued following output of the error message, or instructions to the user are printed for re-entrance of the erroneous card.

A list of these diagnostics, whether they are fatal or not, the subroutine from which they originate, and a brief explanation of each is given in the following chart.

DIAGNOSTICS	FATAL	SUBROUTINE	EXPLANATION
MULTIPLE INPUT FILE NAMES MUST BE SPECIFIED FOR OPERATOR xxx	x	ASSIGN	Operator xxx requires more than one input file and the names have not been provided in parentheses on the operator card.
BAD FILE NAME SPECIFICATION	x	ASSIGN	No comma or close parentheses was found for multiple input file names specified on operator card.
IDENTICAL FILE NAMES NOT ALLOWED	x	ASSIGN	A file name has occurred more than once in a multiple input file name specification.
INCORRECT NUMBER OF FILE NAMES SPECIFIED	x	ASSIGN	Either too many or too few names have been provided in the multiple input file name specification in parentheses.
ERROR-IMAGE ARRAY TOO LARGE. MUST BE 2048 COLUMNS OR LESS FOR INTEGER FILE	x	DISKO	Maximum image size has been exceeded for an integer array.
ERROR - TOO MANY OPEN FILES	x	DISKO	An attempt has been made to open more than the maximum of 7 image files at one time.
ERROR - FILE WITH ID OF xxxxxxx NOT ASSIGNED	x	DISKD	An attempt has been made to delete a non-existent file.
ERROR - FILE WITH ID xxxxxxx NOT OPEN	x	DISKC	An attempt has been made to close a file that has been previously deleted or one that has not been opened.
	x	DISKRD DISKWD	An attempt has been made to read/write on a file which has not been opened (i.e., a buffer has not been assigned to it).
ERROR FILE DIRECTORY ID xxxxxxx CANNOT BE FOUND	x	DISKRD DISKWD	An attempt has been made to read/write on a file which does not have an entry in the disk file directory.

DIAGNOSTICS	FATAL	SUBROUTINE	EXPLANATION
ERROR - SUBSET NUMBER ASSIGNMENT HAS EXCEEDED AVAILABLE BUFFER SPACE		SEGMNT	More than 2048 subsets have been found which fall within the specified thresholds.
TOO MANY CHARACTERS IN DISPLAY LINE - EXCESSIVE CHARACTERS IGNORED		DSPLIN	More than 102 characters provided for display.
DATA CARD FORMAT ERROR - CLEAR CARD READER, CORRECT AND RELOAD CARDS, READY CARD READER		DATAIN	No equals sign was found on first input data table card.
INCORRECT NUMBER OF DATA VALUES PROVIDED - CLEAR CARD READER, CORRECT AND RELOAD DATA		DATAIN	The count of the input values in the tables is not equal to the number of values expected.
ONE OR MORE PARAMETERS IN WRONG FORMAT		INIT	No decimal point found where real parameter required, or decimal point found where integer parameter required.
xxx IS AN ILLEGAL OPERATOR		PRERUN	A card input during a pre-run diagnostic check is not part of a table or a continuation card and the first three characters are not a legal IDAPS operator.
xxx NOT LEGAL OPERATOR - CLEAR CARD READER, CORRECT AND RELOAD CARDS, READY CARD READER		RDC(INIT)	First three characters of name on operator card (card columns 1-3) are not recognized as an IDAPS operator.
ERROR IN INTERPOLATION ROUTINE		FUNGN	System error has occurred in system library routine LAGRNG.
INTERPOLATION ERROR		NSA	System error occurred in system library interpolation routine LAGRAN.
ERROR - xxxxxxxx DATA TRANSFER MAY BE INCOMPLETE OR WRONG		DISKW	System error xxxxxxxx has occurred while attempting to write to disk (system library routine DCHEK).
DATA TRANSFER ERROR - xxxxxxxx		DUMPFD RESTOR	System error xxxxxxxx has occurred while attempting to dump a disk file or write on disk (system library routine DCHEK).

APPENDIX C

PROCESS FOR ADDING AN OPERATOR TO THE IDAPS SYSTEM

A. Subroutine IDAPS2

The array NF must be altered to include information about the new operator. Add

,6HXXX ,A,B,C/

to the DATA declaration for array NF, where XXX are the first three characters in the operator's name, and A, B, and C are defined as follows:

A ~ Number of input disk files to be assigned
B ~ Number of scratch disk files to be assigned
C ~ Number of output disk files to be assigned

The DATA declaration for integer NO and the implied DO delimiter in the DATA statement for array NF, must be incremented to reflect the additional operator.

The section of subroutine IDAPS2 pertaining to the new operator should be in the following format:

```
nn      CALL OPnn
          CALL SCK (I,$nn.00,$6 00)
nn00    CONTINUE
          CALL NEWOP
          GO TO 600
```

where nn by convention indicates the new operator's index into array NF (also contained in integer I). OPnn is the entry for the operator in subroutine INIT, SCK is the driver for the diagnostic package, and NEWOP is the new execution subroutine or subroutine package.

At statement number 200, the GO TO switch must contain the statement number nn.

B. Subroutine INIT

The new operator, if it requires the opening of any disk files or the input of any parameters, must have an entry in subroutine INIT. Here, the parameters are read in by calls to IPARAM, format conversion is performed by a call on CKFMT, and any needed disk files are opened by calls to DISKO.

C. Subroutine SCK

Any diagnostics to be made on the new operator should be checked in subroutine SCK. As in IDAPS2, the operator index is used as a statement number and must be included in the initial GO TO switch.

Checks on dimensions of disk files may be made by calls on SZCK. The diagnostic messages are stored in array B in subroutine MESS. Any additions made to this array must be reflected in the dimensions of the array. The maximum number of characters in a diagnostic message is 46.

D. Subroutine "NEWOP"

After its proper linkage, N, is determined, the subroutine (or subroutine package) NEWOP is inserted in the run deck in the following manner:

